

PHASE I CHARACTERIZATION REPORT

*Naval Air Station
Moffett Field, California*

**Volume 1
Text**

August 1990

Submitted By:

HAZWRAP Support Contractor Office
Martin Marietta Energy Systems, Inc.
Oak Ridge, Tennessee 37831
for the
U.S. Department of Energy

Submitted To:

DEPARTMENT OF THE NAVY
WESTERN DIVISION

NAVAL FACILITIES ENGINEERING COMMAND
SAN BRUNO, CALIFORNIA 94066-0727

CHARACTERIZATION REPORT
PHASE I REMEDIAL INVESTIGATION
NAS MOFFETT FIELD, CALIFORNIA

AUGUST 1, 1990

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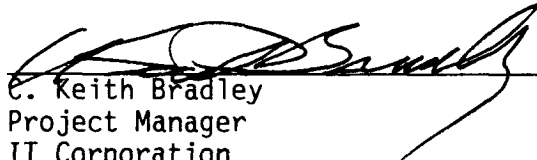
PHASE I CHARACTERIZATION REPORT

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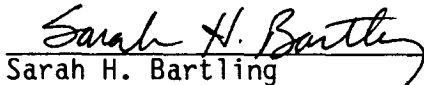
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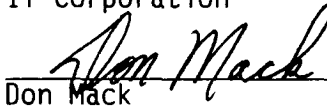
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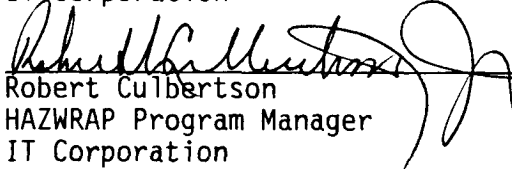
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LIST OF ACRONYMS

AA	Atomic Absorption Spectrometry
ARARs	Applicable, or Relevant and Appropriate Requirements
ASTM	American Society for Testing Materials
ARPA	Advanced Research Projects Agency
AVGAS	Aviation gasoline
BAAQMD	Bay Area Air Quality Management District
BLS	Below land surface
BNAs	Base, Neutral, and Acid Extractable Target Compounds
BTEX	Benzene, Toluene, Ethyl Benzene, and Xylene
CCR	California Code of Regulations
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CRQLs	Contract Required Quantitation Limits
CS	Confirmation Study
CSRS	Confirmation Study Ranking System
CSWRCB	California State Water Resources Control Board
DCA	Dichloroethane
DCE	Dichloroethylene
DERP	Defense Environmental Restoration Program
DHS	California Department of Health Services
DNAPL	Dense Nonaqueous Phase Liquids
DOD	Department of Defense
DWR	California Department of Water Resources
EDC	1,2-Dichloroethane
EM	Electromagnetic
EMB	Embankment Samples
EPA	U.S. Environmental Protection Agency
ESA	Earth Science Associates, Inc.
GC	Gas Chromatograph
GPM	Gallons per minute
GPR	Ground Penetrating Radar
HIR	Hydrogeological Investigation Report

ACRONYMS (continued)

HLA	Harding Lawson Associates
HPLC	High Pressure Liquid Chromatography
IAS	Initial Assessment Study
ICP	Inductively Coupled Plasma Emission Spectroscopy
ID	Inside diameter
IRP	Installation Restoration Program
IT	International Technology Corporation
ITAS	International Technology Corporation Analytical Services
JP	Jet Fuel
K/J/C	Kennedy/Jenks/Chilton
LOEL	Lowest Observed Effect Level
MBAS	Methylene Blue Active Substances
MEK	Methyl Ethyl Ketone (2-Butanone)
MEW	Middlefield-Ellis-Whisman
mg/l	Milligrams per liter
MIBK	Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)
MOGAS	Motor vehicle gas
MSL	Mean Sea Level
mS/m	Milli-siemens per meter
NACIP	Navy Assessment and Control of Installation Pollutants
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NEESA	Naval Energy and Environmental Support Activities
NPL	National Priority List
OD	Outside diameter
P-CRESOL	4-Methylphenol
PAH	Polycyclic Aromatic Hydrocarbon Compounds
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
ppb	Parts per billion
PVC	Polyvinyl Chloride
QA	Quality Assurance

ACRONYMS (continued)

QC	Quality Control
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QR	Quarterly Report
Rm-Ao	Reyes-Alviso Soil Association
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCVWD	Santa Clara Valley Water District
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
Sp-Cv	Sunnyvale-Castro Soil Association
SWAT	Solid Waste Assessment Test
TCA	Tetrachlorethane
TCDD	Tetrachlorinated dibenzo-p-dioxin
TCE	Tetrachloroethylene
TDS	Total Dissolved Solids
TIP	Total Ionizables Present
TOC	Total Organic Carbon
TOX	Total Organic Halogens
USCS	Unified Soil Classification System
USGS	United States Geological Survey
USTs	Underground Storage Tanks
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
WESTDIV	Western Division of the Naval Facilities Engineering Command

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

Regulatory History

The Navy Assessment and Control of Installation Pollutants (NACIP) program was established September 11, 1980, as a component of the Department of Defense (DOD) Installation Restoration Program (IRP). The purpose of the NACIP program was to assess and control environmental effects of abandoned hazardous waste disposal sites at Navy shore facilities. The program is directed by the Naval Facilities Engineering Command (NAVFAC). The Western Division of the Naval Facilities Engineering Command (WESTDIV) is responsible for implementing the NACIP program at Naval Air Station (NAS) Moffett Field. On December 11, 1981, the Navy required that a priority list be developed of contaminated installations and facilities requiring remedial action. In July 1983, investigation under the NACIP program was initiated at NAS Moffett Field. Previous investigations at NAS Moffett Field are discussed in Section 1.4.

On December 11, 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as "Superfund." This law requires that all federal facilities comply with state and federal requirements promulgated under CERCLA. The Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986, renamed the IRP the Defense Environmental Restoration Program (Section 211). In July 1987, NAS Moffett Field was placed on the U.S. Environmental Protection Agency's (EPA's) National Priority List (NPL). It was approximately at this time that the Navy initiated plans to conduct the current Remedial Investigation/Feasibility Study (RI/FS) at NAS Moffett Field. The work plans for the RI/FS were approved March 30, 1988.

Objectives

An RI was undertaken at NAS Moffett Field to address the apparent past contamination problems and to meet the intent of CERCLA and related California environmental regulations as defined in the California Code of Regulations (CCR, Title 23 Subchapter 15).

Specific objectives of the RI are to:

- Confirm, characterize, and define the lateral and vertical extent of chemicals of concern at each site known or suspected to be a source of contaminant release.
- Supplement and refine the existing geologic, geochemical, hydrogeologic, and chemical database for the study sites.
- Evaluate the chemical migration pathways, site hydrogeology, and specifics of ground water movement that influence the migration of site-related chemicals.
- Evaluate potential risks and hazards to public health and the environment.
- Provide data adequate to assess the need for interim remedial actions and to adequately design such actions.

In addition to meeting these objectives, additional studies were performed during the course of this program to comply with specific state requirements. These coincident activities included evaluating two landfills, Sites 1 and 2 by conducting a Solid Waste Assessment Test (SWAT) for those sites in accordance with the California Water Code, Section 13273. Additionally, a Screening Questionnaire for Inactive Solid Waste Disposal Sites was completed and submitted to the Bay Area Air Quality Management District in accordance with California Health and Safety Code Section 41805.5.

Scope of the RI

The RI is being conducted in a series of steps or phases at NAS Moffett Field. Phase I documents the types and concentrations of chemicals of concern present at the various study sites. Phase II will refine the lateral and vertical extent of target chemicals throughout the facility. Also during Phase II, sufficient data will be obtained to allow for numerical simulation of chemical fate and transport over time. Phase III of the RI will fill in any remaining gaps in the data base and will be designed to provide engineering data for the feasibility study and any pending remediation.

This Characterization Report describes Phase I studies. An Operable Units Report will follow Phase II studies.

1.2 ORGANIZATION

The organization of this Characterization Report is as follows:

- Section 1 provides an introduction, including purpose, organization, project background, and previous studies.
- Section 2 discusses the Phase I RI activities including data review, field and laboratory activities, and public health evaluation.
- Section 3 provides the reader with a description of the environmental setting including background levels of chemicals at NAS Moffett Field and vicinity.
- Sections 4 through 22 provide a description and environmental history of each site, and present the Phase I investigation results for each site.
- Section 23 describes typical environmental behavior and persistence characteristics of site contaminants.
- Section 24 is a discussion of the preliminary qualitative risk assessment and includes a receptor survey.
- Section 25 completes the Phase I characterization report by providing summary and conclusions.

All data are presented in a summary fashion. Complete data sets are provided in the quarterly reports which have been published since 1988 and are available to the public at NAS Moffett Field, EPA-San Francisco and at the City of Mountain View Library. Summary tables of analytical data are presented as Appendices. Tables and figures are provided at the end of this report as separately tabbed sections.

1.3 PROJECT BACKGROUND

1.3.1 NAS Moffett Field Location and Description

NAS Moffett Field is located in the Santa Clara Valley near the southern end of San Francisco Bay, 35 miles southeast of San Francisco, California, and 10 miles northwest of San Jose, California. The installation encompasses approximately 2,200 acres in Santa Clara County. NAS Moffett Field is bordered by the Cities of Mountain View on the west and Sunnyvale on the south (Figure 1.3-1).

The facility is bounded by salt evaporation ponds to the north, Stevens Creek to the west, U.S. Highway 101 to the south, and Lockheed Missiles and Space Company's Lockheed Aerospace Center (Lockheed) to the east. The principle access to NAS Moffett Field is through the Main (North) Gate. The same entrance is also used for the National Aeronautics and Space Administration's (NASA's) Ames Research Center which is located to the west of NAS Moffett Field but within its perimeter security fence.

NAS Moffett Field is essentially divided in half by the runway system that is oriented northwest-southeast. Most of the aircraft and flight training operations are on the east side of the runway and the administrative support operations and functions are on the west side (Figure 1.3-2). There are 380 structures at NAS Moffett Field. Many of these buildings were built by the U.S. Army when it occupied the base in the early 1940s.

Since the 1950s, the area surrounding the facility has become increasingly populated, and very little land is available that is not committed to urban land uses or tidelands. The encroaching urbanization around the facility has been evident for some time. This has been demonstrated by community pressure to reduce noise levels and increase air safety. The Navy responded in the summer of 1961 by moving jet operations to Lemoore Field and utilizing the quieter and safer turbopropeller P-3C Orions.

The station has been in continuous operation by the military since it was commissioned in 1933. A variety of national defense missions have been executed by the station, including the present support of the Pacific Fleet Air Patrol Forces. The current mission of NAS Moffett Field is to support anti-submarine warfare training and patrol squadrons. Today, more than 5,500 military, 1,500 civilian, and 1,000 reservist personnel support nearly 100 P-3C Orion patrol aircraft assigned to nine squadrons. Although no heavy manufacturing or major aircraft maintenance is performed at NAS Moffett Field, a significant amount of intermediate level maintenance is accomplished.

The station supports more than 70 tenants - the most important being the Commander Patrol Wings, U.S. Pacific Fleet. Additionally, NAS Moffett Field supports the California Air National Guard.

Other groups supported by NAS Moffett Field include:

- Naval Air Maintenance Training Detachment 1012
- Naval Aviation Engineering Service Unit
- Fleet Aviation Specialized Operation Training Group, Pacific Detachment, NAS Moffett Field
- Explosive Ordnance Disposal Unit Detachment, NAS Moffett Field
- Branch Dispensary, Naval Regional Medical Center, Oakland
- Branch Facility, Naval Regional Dental Center, San Francisco
- Department of Defense, Advanced Research Projects Agency (ARPA)
- Defense Property Disposal Office, Alameda.

Minor support is provided to the Naval Academy, Flying Club, printing office, and communications/training/research and development. Minor support is also provided to other military installations for vehicle maintenance and to private companies engaged in electronics.

NAS Moffett Field affects the economic base of the local community and the region. Most of the 7,000 military and civilian personnel at NAS Moffett Field reside in the immediate area and provide property revenues to the local county and city governments. Additionally, this population also contributes to the local economy through the purchase of consumer goods, utilities, and services. Revenues are also realized through sales tax, vehicle fees, licenses, and permits.

1.3.2 NAS Moffett Field Environs

For the past several thousand years, the Santa Clara Valley has been influenced by four sequential cultures: Indian, Spanish, Mexican, and American. The area evolved from a grassland/forest wilderness environment populated by Indians, through an agricultural era during the Spanish land grant period and the Mexican mission period, to the current "modern" times of intense light industrial and urban development.

More than 1.3 million people reside in Santa Clara County and the population is continuing to grow. NAS Moffett Field is bordered by the Cities of Mountain View and Sunnyvale, California. The City of Mountain View is located on the west side of NAS Moffett Field. Mountain View was primarily an agricultural community until the 1930s. Since the U.S. Navy commissioned NAS Moffett Field in 1933, Moffett Field and the NASA Ames Research Center have been two of the largest employers in the area. The other main industry is electronics. During the past 15 years, many electronics firms have established themselves in and around Mountain View. Presently, Mountain View's residential population of 61,000 increases to 120,000 during business hours, when "Silicon Valley" workers commute into the area.

The City of Sunnyvale is located east of Mountain View and adjacent to the southern border of NAS Moffett Field. The population of Sunnyvale is more than 114,000 and, like Mountain View, the population increases during working hours. There are over 525 manufacturers/wholesalers in Sunnyvale. The leading types of industry are research and development, high technology, and aerospace. Lockheed is the largest employer, with a workforce of approximately 25,000 persons.

Lockheed is the eastern neighbor to NAS Moffett Field. The firm is involved in designing and manufacturing missile and space systems. It has designed and built several submarine-launched missile systems and has worked with NAS Moffett Field on various electronic systems installations in patrol aircraft.

1.4 PREVIOUS STUDIES

1.4.1 Initial Assessment Study

The first phase of the NACIP program was the Initial Assessment Study (IAS). The IAS for NAS Moffett Field was conducted for the Naval Energy and Environmental Support Activity (NEESA) from July 1983 to April 1984, and nine potentially contaminated sites were identified. Based on information from historical records, aerial photographs, surface surveys, and personnel interviews, it was concluded that eight sites at NAS Moffett Field could pose sufficient threat to human health or to the environment to warrant a Confirmation Study

(CS), the second phase of the NACIP program. The eight sites identified at that time for the CS (with current RI/FS site numbers) were:

- Site 1 - Runway Landfill
- Site 3 - Marriage Road Ditch
- Site 4 - Former Industrial Wastewater Holding Pond
- Site 5 - Fuel Farm French Drains
- Site 6 - Runway Apron
- Site 7 - Hangars 2 and 3
- Site 8 - Waste Oil Transfer Area
- Site 9 - Old Fuel Farm.

The golf course landfill, Site 2, was not recommended for a CS. The IAS reached the decision based on the document's conclusions that human health and the environment would probably not be threatened from any contamination at the site because of the age of the site and that ground water from the site would probably not enter San Francisco Bay. However, the IAS did state that if significant contamination was found at Site 1, a CS should be considered for Site 2 because of the similarities between the two sites.

1.4.2 Confirmation Study

The objective of the CS phase was to quantify the concentrations of hazardous chemicals present and define the areal and vertical extent of contamination. The sequential steps of the CS were as follows:

<u>Step</u>	<u>Description</u>
I	Verification - Verify the existence of contamination.
II	Characterization - Characterize the extent and rate of migration of contaminants.
III	Feasibility - Evaluate remedial alternatives to achieve compliance, prepare cost estimates, and assess effectiveness of alternatives.
IV	Project Documentation - Prepare a site operation plan and project documentation including cost estimates suitable for funding requests.

In June 1985, WESTDIV authorized Earth Science Associates, Inc. (ESA) and James M. Montgomery Consulting Engineers to conduct Step I of the CS, Verification Step, (ESA, 1986a).

ESA subsequently prepared a work plan for Step II (Characterization Step) of the CS that described additional studies to be conducted at each of the eight original sites (ESA, 1986b). In addition, two new sites identified during sampling for the verification step were also included. The two additional sites identified were the Golf Course Landfill (Site 2) and Chase Park Runway areas (Site 10), thus bringing the total number of sites under investigation to ten in 1986.

1.4.2.1 Verification Step (Step I)

The main purpose of the Verification Step was to establish the presence or absence of contamination at each site identified in the IAS. The verification study report (ESA, 1986a) contains general information on the geology and hydrogeology of the NAS Moffett Field area and includes the results of chemical analyses on soil and ground water samples from new and previously existing wells within each study area. Soil samples used for chemical analyses were taken during field drilling operations.

1.4.2.2 Characterization Step (Step II) Work Plan

The focus of the Characterization Step was to provide the additional data and analyses needed to further define the concentrations and distribution of chemical compounds that were previously identified in ground water beneath and adjacent to the sites. Further, a refinement of the current state of knowledge on contaminant migration and the hydrology and hydrogeology of the sites were also goals of the Characterization Step.

The work plan for the NAS Moffett Field Characterization Step identified the following nine specific tasks to accomplish:

- Pre-site investigation
- Quality Assurance Project Plans for the laboratory analyses and field operations
- Sampling Plan
- Health and Safety Plan
- On-site field investigations
- Chemical analyses of groundwater samples
- Characterization Study Report

- Assessment of public and private wells that may act as potential conduits for inter-aquifer cross contamination
- Meetings with regulatory agencies.

Before execution of most of this work, the NACIP program was replaced in 1987 with the IRP which is organized more closely to the EPA's RI/FS process. The Navy, where possible, incorporated the NACIP work into the IRP (RI/FS). Thus, Steps III and IV of the CS, were not completed.

1.4.3 Potential Vertical Conduits

Previous investigations of potential vertical conduits (vertically oriented channels such as wells that may transport contaminants) on or near NAS Moffett Field were performed by Harding Lawson Associates (HLA) in 1985 and Canonie Engineers (Canonie) in 1986. The HLA study evaluated the area of an NPL site located south of Highway 101 termed the Middlefield-Ellis Whisman (MEW) area and a portion of the station whereas the Canonie study encompassed all of the station.

ESA produced a potential vertical conduits report for NAS Moffett Field (ESA, 1986c). The report lists wells located at NAS Moffett Field identified in the MEW study and additional wells located on the northern portion of NAS Moffett Field that were not covered by the MEW study. The report was produced as part of the CS. Two inactive wells, 14M01 and 14M02, were sampled once as part of the CS. Sample results reported by ESA for volatile organic compounds (VOCs) indicated a low level of VOC contamination.

Following the ESA study, WESTDIV prepared a potential conduits study work plan which contained a list of the wells identified by ESA and called for a records search for any additional suspected wells. To supplement the characterization study, a potential conduits investigation was implemented to complete the tasks in accordance with WESTDIV's work plan. The investigation, performed by Kennedy/Jenks/Chilton, produced three reports: Suspected Wells Research Report (K/J/C, 1988a) that located wells identified in previous studies by field surface geophysical techniques; Active Wells Report (K/J/C, 1988b) that characterized the four active irrigation wells; and Suspected Wells Investigation Report (K/J/C, 1989) that provided additional information on suspected wells from field evaluations.

1.4.4 Tank and Sump Testing

During June 1986, ERM-West (ERM-West, 1986a) and Aqua Resources identified active and inactive underground storage tanks (USTs) that might require investigation or closure. The work was required to comply with regulations promulgated by the State of California and Santa Clara County (ERM-West, 1986a). The study identified 33 USTs, 12 sumps or containment facilities, and 2 ponds that would require further study. The tanks, sumps, and ponds that were identified under the Navy's IRP are listed in Tables 1.4-1 and 1.4-2. These tables provide tank/sump/pond numbers, type, site number where the tank/sump/pond is located, and work to be completed.

Results of investigations on potential soil and ground water contamination near abandoned tanks and leak testing of 26 active underground tanks in 1987 (ERM-West, 1987) brought the number of potentially contaminated sites at NAS Moffett Field to 19 (Table 1.4-3). Some of the UST sites are discrete individual locations while others are comprised of multiple locations. The respective locations of the 19 sites are presented in Figure 1.4-1. A description of the sites are provided in Sections 4 through 22.

1.4.5 Hydrogeologic Assessment Study of Wastewater Flux Ponds

NAS Moffett utilizes two earthen ponds for storage and treatment of industrial wastewater. The ponds are unlined and have a combined storage capacity of 400,000 gallons.

Figure 1.4-2 shows the location of the flux ponds at NAS Moffett Field. The ponds are located at the northeast corner of the station and are bounded by the golf course to the north and east and paved aircraft taxi and tie-down area to the west and south. The flux ponds were constructed in 1975 to replace the original pond that was closed and removed (Site 4).

A Hydrogeologic Assessment Report for the industrial wastewater flux ponds, prepared for the Navy by Dames and Moore (Dames and Moore, 1988a), summarizes the following items:

- Construction and operation of the ponds
- Chemical characteristics of the waste discharged to the industrial wastewater flux ponds
- Chemical characteristics of surface water and sludge
- Physical and chemical properties of the vadose zone beneath the site
- Regional (within 1-mile radius) and local surface water and ground water hydrology
- Local climatology in the Sunnyvale area
- Regional and site specific geologic setting.

Based upon information collected during the investigation (Dames and Moore, 1988a), the wastewater flux ponds do not contain hazardous waste as defined under Title 22, Division 4, Chapter 30, Article II of the CCR. Volatile and semivolatile organics were not detected in samples from the pond water, sludge, or in the soil beneath the ponds. Metals were present at nonhazardous concentrations in samples from the pond water, sludge, and soils beneath the pond.

The wastewater flux ponds are located in an area that could be affected by ground water contamination from other sources. However, based on data collected from monitoring wells located upgradient and downgradient of the ponds, there is no indication that the ponds are affecting ground water quality (Dames and Moore, 1988b).

2.0 PHASE I REMEDIAL INVESTIGATION ACTIVITIES

2.1 INTRODUCTION

The Phase I investigations described in this report were intended to provide a basis for subsequent RI (Phase II and III) studies. A wide variety of investigative techniques were employed during Phase I to identify the extent and character of contamination across the facility. These techniques included:

- Review of historical photographs
- Surface geophysics
- Subsurface geophysics
- Soil gas surveys
- Surface water and stream sediment sampling
- Shallow and deep soil sampling
- Monitoring well installation
- Land surveying
- Ground water quality sampling
- Water level measurements and aquifer testing.

All methods and procedures used for this study conformed to a comprehensive quality assurance (QA) program (IT, 1988a). Variances and changes in conditions were documented on specially designed forms. Each of the following subsections will summarize the technical approach followed during the Phase I investigation. More detailed descriptions of the methods and procedures may be found in the Final Work Plan Vol. II Sampling and Analysis Plan (IT, 1988b). Results of the studies will be discussed in succeeding chapters on a site-by-site basis.

2.2 REVIEW OF HISTORICAL PHOTOGRAPHY

Periodic aerial photographs of Moffett Field are available from 1947 to 1981. An early interpretation of the photographs with regard to the historical development of the Site 1 landfill is provided by ESA (ESA, 1986a). Interpretation by IT included the aerial photographs used by ESA and additional photographs available from local sources. Historical aerial photography for Sites 2, 3, 7, and 19 were also investigated. Aerial photographs provided little information on the remaining sites on the base, however. Noteworthy observations are described for Sites 1, 2, and 3 in the following section.

2.2.1 Sites 1 and 2

The approximate boundary of the Site 1 landfill, as indicated by the aerial photographs, is shown on Figure 2.2-1. Photographs from 1947 to 1981 show the gradual development of the landfill. The area north of the runway started as marsh land, which was diked in 1950 to allow for a runway extension. Following the runway extension in the 1960's, the landfill was developed. The runway was extended northward during the 1970s to its present location (Figure 1.4-1). The 1963 photographs reveal a relict meandering stream channel which crosses the overrun area at the north end of the runway and goes across the Site 1 landfill area to Jagel Slough. The stream appears to have been extensively excavated by equipment in the landfill area. By 1967 the stream cut had been filled in. The reason for the excavation is not apparent. In 1972, a lagoon or pond appeared in the northwest part of the landfill. Due to the lack of vehicle tracks leading to the lagoon, it did not appear to be used for disposal. The lagoon was filled in by 1974 and by 1975 the entire site was graded and is no longer used.

A 1947 photo shows the Site 2 golf course landfill in operation. The landfill appears as a shallow excavation, the boundaries of which are indicated on Figure 2.2-2. The aerial photo shows little change in the landfill until it was totally filled and abandoned in 1963.

2.2.2 Site 3 Marriage Road Ditch

Review of the 1947 aerial photo indicates the presence of several barracks buildings and what appears to be an area of excavation and fill. The buildings were located on the southeast corner of Marriage and Patrol Roads. Located in the same area as the buildings, but extending much further east along Patrol Road, is an area of cut-and-fill. There was no change in the Site 3 area until 1960 when the golf course was constructed. The buildings and excavations still existed then. By 1970 the golf course was extended and replaced the cut-and-fill area. The buildings on the corner of Marriage and Patrol Roads were replaced with one small building.

2.3 FIELD INVESTIGATION ACTIVITIES

2.3.1 Surface Geophysics

Geophysical surveys were conducted at all proposed monitoring well locations, along transect lines and at proposed geophysical boring locations. These surveys aided in the detection of underground obstructions as well as electrical and sewer lines. Terrain conductivity, resistivity, and magnetic methods were used, depending on the configuration of buildings and metallic structures which would affect certain survey methods. Upon completion of the surveys the geophysical contractor provided an interpretation of the data and suggested acceptable boring and transect line locations.

Surface geophysical methods were used at Sites 1 and 2 to delineate the extent and depth of landfill materials. Surface geophysics were also utilized to clear the monitoring well, soil gas transect line, and geophysical boring locations. Terrain conductivity, surface resistivity, and magnetic methods were used to accomplish these objectives. Surface geophysical methods used the low resistivity, high conductivity, and low magnetic susceptibility of the native substrata to detect landfill material and buried obstructions. The data and maps from the landfill surveys are included in the March 1989 SWAT report. Geophysical surveys consisting of terrain conductivity and resistivity (vertical electric sounding) were used to estimate the lateral extent and thickness of the Site 1 landfill. Contrasts in conductivity allowed the detection of the fill-native soil contact and provided an approximation of the landfill limits.

Geophysical surveys at Site 2 included terrain conductivity, terrain resistivity, and magnetic methods. The objectives of the surface geophysics at Site 2 were similar to Site 1, with the extent and depth of landfill material the primary targets. The suspected presence of ferromagnetic metallic materials required the use of magnetic methods at Site 1 and Site 2.

2.3.2 Borehole Geophysics

Borehole geophysical methods were used to allow accurate recognition and delineation of stratigraphic units and aquifer zones and aquitards and to facilitate selection of the correct interval for installation of well

screens. The 4.5 inch OD boreholes were advanced by mud or air rotary methods to a depth ranging from 232 to 257 feet below land surface. During the drilling of each borehole a continuous soil core was collected to provide detailed lithologic descriptions. Boreholes were twinned with planned Phase I monitoring wells. This resulted in accurate lithologic correlation between the wells and the delineation of desired aquifer material before drilling of the monitoring well. The following borehole geophysical tools were used during each logging run:

- Natural Gamma - Measures naturally occurring radiation. Used for stratigraphic correlation and defining permeability by determining clay percentage.
- Spontaneous Potential - Measures naturally occurring electrical potentials. Used for locating chemical and physical changes in geologic material.
- Resistivity - Measures resistance of various geologic material to the flow of electrical current. Used to locate tops and bottoms of distinct stratigraphic units.
- Caliper - Measures variations in borehole diameter. Used mainly to locate breakout areas and swelling clays.

2.3.3 Surface Water and Sediment Investigations

Much of the runoff from NAS Moffett Field is diverted into a single receptor ditch on the northeast portion of the base. Water from this ditch is pumped off site into a drainage canal which eventually drains into Guadalupe Slough. Surface water and sediment sampling from this ditch were conducted in wet and dry seasons near Sites 1 and 2.

Samples were collected from the salt evaporator pond to the north of Site 1 and from the marsh and slough area to the east (Figure 2.3-1). Dry season water and sediment samples were collected during August, 1988. Wet season water samples were collected during months of January and February, 1989.

A surface water grab sample and sediment core sample were collected at one location, Jagel Slough-2, which may have been affected by the Site 2 landfill (Figure 2.3-2). A wet season water sample and sediment sample were collected

in January 1989 and February 1988, respectively. A dry season water and sediment sample were collected in August and July 1988, respectively.

The analyses performed on surface water and sediment samples are described in Section 2.4.

2.3.4 Soil Gas Surveys

Soil gas surveys were part of the field investigation for Sites 3, 5, 9, 10, and 12. The objectives of these surveys were to: (1) evaluate the distribution of volatile chlorinated and petroleum hydrocarbons in the vadose zone, and (2) identify potential ground water contaminant source areas. Based in part on the results of the soil gas surveys, additional Phase II monitoring wells will be located and sampled to quantify the levels of hydrocarbons in the shallow ground water.

Soil gas samples were taken in the field using a photoionization detector and reported as Total Ionizables Present (TIP). The TIP detector measured total ionizable compounds with a 10.2 ev UV source relative to an isobutylene standard and has an equipment resolution of 1.0 ppm. Where TIP measurements were greater than 1.0 ppm, a soil gas sample was collected in a Tedlar® bag for analysis by a portable field gas chromatograph (GC). The GC analysis was used to quantify the following compounds:

- 1,1-DCE
- 1,1-DCA
- cis-1,2-DCE
- 1,1,1-TCA
- TCE
- 1,1,2-TCA
- benzene
- toluene
- m-xylene
- o-xylene.

Several of these compounds are known to exist at the MEW location and several are byproducts of fuel and lubricants. The GC method is applicable to determining 10 to 10,000 ppb levels of TCE in soil gas samples. Where a substantial number of sample points in an area had TIP-measured concentrations above 1.0 ppm, only selected samples were analyzed by GC. Sample stations with the

highest total ionizable compound concentrations were sampled for GC analysis. Where the GC analysis identified several compounds in a sample area, additional samples were collected for GC analysis to assess the distribution of the various compounds.

Soil gas samples were collected uniformly from approximately 5-foot depths, at 50- to 100-foot intervals along transect lines. A complete description of this sampling method and original locations of transect lines is in the Sampling and Analysis Work Plan in Appendix G of the December 1988 Quarterly Report (IT, 1988e). Following completion of the initial screening lines using the TIP detector, additional transect lines were delineated for areas where levels of volatile organic compounds (VOCs) were above background (ambient air measured at the sample station). In excess of 160 readings were collected over 10,000 feet of transect lines.

2.3.5 Soil Sampling

Soil samples were collected from augered soil borings, monitoring well borings, and shallow hand driven borings. Soil borings were augered at Sites 1, 2, 3, 5, 7, 8, 11, 12, 13, 14, and 19. Augered borings were generally advanced to a depth of 10 feet unless ground water was encountered at a shallower depth. Samples for chemical analysis were generally collected at 1-, 3-, and 5-foot depths. Because of the variability of the refuse at Site 1 and Site 2, soil samples were collected at various depths ranging from 1 to 29 feet. Depending on the water table depth, a fourth sample was collected from immediately above the water table or at 10 feet, whichever was more shallow. Shallow, hand-driven soil samples (1 foot) using brass tubing were collected at Sites 1, 3, and 11. The analyses performed are described in Section 2.4.

Soil Sampling Methods

The primary purposes of collecting soil samples were:

- Lithologic identification and logging of the soils
- Chemical analysis of the soils.

Soil samples from borings were collected using a California modified split-spoon drive sampler, which consists of an outer 18-inch long steel barrel into which three 6 inch-long x 2 inch-diameter sample sleeves were inserted.

Wells installed in the uppermost aquifer (A aquifer) were drilled using the hollow-stem auger method. Each borehole was continuously cored using a 5-foot long (2-inch diameter) California modified sampler. As a result, good descriptions of materials penetrated were obtained in zones where adequate core recovery was achieved. Wells installed in the second and third aquifer systems (B and C aquifers, respectively) were drilled using the casing hammer method and were logged by examination of the drill cuttings collected from the discharge system. Periodic split-spoon drive samples were taken to confirm soil descriptions.

The boreholes which were geophysically logged were backfilled with grout and abandoned after logging was completed. Geophysical logging was conducted at Sites 1, 2, 3, 4, 5, 7, 8, 9, 10, 14, and 19. Geophysical logs were presented in the December 1988 Quarterly Report (IT, 1988e). Good correlation between geophysical logging and stratigraphy was achieved which enhanced the construction of geologic cross-sections using the geophysical data.

2.3.6 Well Installation

Well installation activities began in May 1988 and were completed in November 1988. Well installation efforts included 46 A aquifer, 14 B aquifer, 8 C aquifer, and 7 landfill leachate monitoring wells. The locations of these wells are shown on individual site location maps contained in Chapters 4 through 22 of this report.

The objectives of the drilling investigations at NAS Moffett Field during Phase I RI were:

- Provide an opportunity for a detailed lithologic evaluation (logging) of soils collected as cores in order to establish the subsurface stratigraphy at the locations of proposed wells
- Determine locations for ground water quality monitoring.

Before drilling at NAS Moffett Field, utility drawings such as fuel, electrical, sewer, and water lines, and any other buried features that might have impacted the location of boreholes were reviewed. Magnetometer, electromagnetic (EM), and/or ground-penetrating radar (GPR) surveys were used to identify buried obstructions (Section 2.3.1).

All drilling, sampling, and well construction methods followed California State and local Santa Clara Valley Water District (SCVWD) guidelines (SCVWD, 1989). A qualified geologist visually logged each borehole using cored samples and drill cuttings. Lithologic logs were prepared using the Unified Soil Classification System (USCS) (Table 2.3-1).

Two drilling techniques were used to install monitoring wells, (1) hollow-stem auger for the shallowest wells (A aquifer), and (2) casing hammer for landfill leachate and B and C aquifer wells.

Construction Methods For Well Installation

Target depths for well screens were selected on the basis of the most recent and reliable lithological, hydrological, and geophysical information from adjacent existing borings and wells. Regional and local stratigraphic settings and trends were also taken into account in targeting the screened intervals in specific aquifers (Canonie, 1985, 1986, 1987; EMCON, 1983a, 1983b; ERM-West, 1986a, 1987; ESA, 1986c; Golder 1987; HLA, 1986, 1987a; K/J/C, 1982, 1987; NEESA, 1984).

Most wells were constructed of 4-inch nominal diameter grade "B" steel casing and 4-inch nominal diameter Type 304 stainless steel screen; an exception on materials was made for Sites 1 and 2 due to the highly corrosive environment (conductivity >5,000 micromhos). At these locations, Schedule 40 PVC casing and screen were used. Filter pack material consisted of clean, well-rounded, quartz sand which was uniform in size. Screen slot size was 0.010-inch factory milled. The minimum annular space between the well casing and boring wall was 2 inches. Well casing was square-threaded and flush-jointed. Typical construction details for the monitoring wells are shown on Figure 2.3-3.

A 12-inch diameter continuous flight hollow-stem auger was used in drilling wells in the uppermost aquifer (A aquifer). A core sample was collected by a tube sampler through the hollow stem, ahead of the auger. After the boring was completed to total depth, the well screen, well casing, sand pack, and the annulus seal were installed through the hollow stem as the flights were being removed from the boring.

The casing hammer drilling method was used for wells drilled below the uppermost aquifer (B and C aquifers). This method advances a rotary drill bit along with steel drive casing. The drill bit, 0.5 to 2.0 feet ahead of the casing, cuts the earthen materials and the cuttings are forced upward by mud or air pressure inside the drive casing to the surface. As a result, aquifers are effectively isolated from the boring after they are penetrated and interaquifer communication is avoided.

All wells were drilled to a minimum of 5 feet into the aquitard below the targeted aquifer. Where the aquitard (beneath the targeted aquifer) was less than 5 feet thick, the hole was backfilled with bentonite pellets to a level that was within an aquitard. The screened interval was 5 feet in length, or multiples thereof, depending on the thickness of the local aquifer material. A square-threaded cap was installed at the base of the screened section. Casing centralizers were installed on the deeper wells to ensure proper well casing placement. Filter sand pack was tremied in adjacent to the screen and extended to 2 feet above the top of the screen. A 1- to 2-foot-thick bentonite pellet seal was placed above the sand pack. The annulus above the bentonite seal was filled via tremie pipe with cement grout (6.5 gallons of water per 94 pounds of Portland cement) containing approximately 5 percent bentonite. After each well was completed, cement seals were allowed to set for a minimum of 24 hours prior to well development.

An expandable, waterproof cap, and a watertight locking steel casing cover was placed on the well casing below grade and protected with a "Christy box" and steel plate at grade level. In areas without vehicular traffic, the well casing extended above ground approximately 1 to 3 feet and was enclosed in a 6-inch-diameter steel clasp locking standpipe. When necessary, the standpipe was surrounded by protective traffic bollards.

The B and C aquifer wells were installed using the air-rotary casing hammer drilling method. Appropriate depths were selected based on the occurrence of a distinctive sand and/or gravel unit, geophysics, and the occurrence of water. The boring was drilled through the aquifer of interest and 5 feet into the underlying aquitard. Upon completion of the borehole, well construction was carried out as described previously. The drive casing was withdrawn as the filter pack, bentonite, and grout were tremied into the boring. Well construction details including the total depths, location coordinates, screen type, and screen intervals are compiled for all 75 wells and selected wells installed by others (total of 107 wells) in Table 2.3-2.

Well Development Method

Each well was developed by swabbing and pumping. Swabbing, or the rapid removal of water with a close pitting bailer, was used to clean and develop the well, while solid debris were removed using the bailer method. The well was then further developed by pumping. A pump was lowered into the screened interval and the well pumped at increasing flow rates until clear water flowed continuously from the well. This technique was successful for 74 of the 75 wells constructed at Moffett Field. Well W4-11A was abandoned when aquifer material was not encountered.

Decontamination

Decontamination procedures, as described in the Sampling and Analysis Plan (IT, 1988b) were followed during well installation. Before starting a well, the drill rig and all related equipment were steam cleaned. Before collection of each soil sample, all sampling equipment was also decontaminated. The method of cleaning was to:

- Scrub off large particles with brushes and low alkaline nonphosphate detergent solution
- Double rinse with deionized water
- Final rinse with ASTM type 2/HPLC water.

2.3.7 Permeability Tests

In-situ permeability tests were performed in selected boreholes at Sites 1 and

2 by the rising head slug test method. The tests were conducted in a 2-foot interval of cohesive natural material underlying the base of the fill. The hole was blown dry with compressed air and the rise in water level inside the casing was measured for up to 4 hours. After the completion of the test, the bottom 2 feet of the well was backfilled with bentonite and a leachate monitoring well was completed in the fill material. For the purpose of calculating hydraulic conductivity, the slug was assumed to be the volume in the boring between the stabilized water level and borehole bottom (stabilized water level is assumed to be the static water level which is measured following completion of the test). The test is assumed to start when the air compressor is stopped. The test data were analyzed by the method developed by Cooper, et al. (1967).

2.3.8 Water Level Measurements

Water level data were collected monthly (August 1988 to October 1989) from 109 wells to provide seasonal characterization of the potentiometric surface in the different hydrologic units. Data were used to construct ground water contour maps and to establish horizontal and vertical flow directions. In addition to the monthly collection of water levels, continuous ground water levels were obtained at selected locations to ascertain the tidal effects on ground water flow.

An electric water level indicator accurate to 0.1 foot was used to detect the ground water surface in new wells as well as several MEW and ESA wells. Table 2.3-3 lists the existing wells in which water level measurements were taken. The elevations were taken from the reference point established during the surveying of each well, and converted to mean sea level (MSL). Water level readings were recorded on appropriate forms. All parts of the water level probe which came in contact with the well water were cleaned with a low alkaline, nonphosphate detergent solution, and rinsed with deionized water between each well.

Continuous (12 hour duration) water level monitoring was performed in selected wells, based on their proximity to the San Francisco Bay. They include:

- W1-5(A1)
- W1-7(A2)
- W2-5(A1)
- W2-6(A1)
- W2-7(A2)
- W3-22(A2)
- W3-23(A1)
- W7-21(A1)
- W11-1(A1)
- W19-1(A2)
- W3-12(A2)
- W3-13(A2)
- W19-2(A2)
- W5-5(C).

As previously mentioned, the objective was to identify what effects, if any, the daily tidal fluctuations had on the three aquifer groups (A, B, and C). These data in turn provided a means to normalize water level data to a mean tide datum. Water levels in the selected wells were monitored for a 12-hour period using a continuous strip chart recorder, which spanned two tidal changes.

2.3.9 Ground Water Sampling

Ground water samples were obtained from 107 wells located at 14 of the 19 sites. The wells can be grouped into two categories: 1) 32 preexisting wells installed by other investigators and 2) 75 wells installed as part of this study. Each well was sampled a minimum of four times on a quarterly basis for one year. During the first quarter, two additional rounds of samples were taken from 74 of the 75 wells installed in this study. Well 4-11A did not contain water. All monitoring well samples were collected between August 1988 and September 1989.

Samples were obtained from the wells using either dedicated bladder pumps or, in the case of the preexisting wells, by Teflon™ bailer. All sampling was preceded by well purging in accordance with the Sampling and Analysis Plan (IT, 1988b). In the event of a well being purged dry (insufficient well yield to obtain the calculated purge volume) the removed volume of water was properly documented on a Sampling Information Form and the well allowed to recharge to 80 percent of its static well volume prior to being sampled in accordance with procedures established for low yield wells. A variation to this procedure was

adopted for the leachate, or fill, wells located at Sites 1 and 2. The leachate wells, identified by having the letter "F" (e.g., W1-10F) included in their well identification, were constructed so that leachate could be characterized. Because these wells were not completed in a true aquifer and have extremely low recharge rates, only one well volume was removed prior to sampling. All water removed during the well purging process was contained in on-site portable tanks. As a tank became full, a representative sample was obtained and analyzed to confirm acceptance for disposal to the local sanitary sewer system.

QA samples for soil, surface water and ground water were collected in accordance with established QA procedures (IT, 1988a). Field duplicate samples were collected at a frequency of 10 percent per sampling event. A sampling event was defined as any sampling activity not separated by a 24-hour period of inactivity. Other types of QA samples included field blanks, VOA trip blanks, split samples, matrix spikes, and matrix spike duplicates.

Upon completion of a sampling day, all ground water samples were packed with "blue ice" in ice chests and sent overnight via Federal Express to the IT Analytical Laboratory in Cerritos, California for analysis. Requested testing programs for each sample were obtained from Table 4 of the Sampling and Analysis Plan and listed on appropriate Request for Analysis forms. Established Chain of Custody procedures were followed during all field sampling (IT, 1988b).

2.3.10 Surveying

Installed monitoring wells and borings were surveyed for vertical and horizontal control. Existing wells which lacked survey data were also surveyed. The wells were surveyed in relation to the California Coordinate System. Elevations were measured to a precision of .01 foot, and horizontal control was surveyed to a precision of 0.1 foot. All elevations were referenced to the same benchmarks used in the MEW Study Area.

The 30 geophysical borings were surveyed from ground level after the holes were abandoned. The 75 study wells were surveyed from the northern-most point at the top of the monument. Selected soil borings and surface water sample loca-

tions were surveyed at Sites 1, 2, 3, 5, 14, and 19. Selected existing wells were surveyed at Sites 1, 3, 4, 6, 7, 8, 9, 10, 14, and 19.

2.4 CHEMICAL ANALYSES

All chemical analyses with the exception of dioxins and furans were analyzed at the ITAS laboratory in Cerritos, California. The Cerritos facility participates in the EPA Contract Laboratory Program (CLP) and is also certified (Certificate E727) by the California Department of Health Services (DHS) for water and hazardous waste analyses. The ITAS Knoxville high-hazard laboratory performed dioxin and furan analyses. Currently the DHS does not give certification for this type of work.

Chemical analyses for this project were performed following the standardized protocols required by the CLP. These protocols include specific requirements regarding how compounds are analyzed and identified and how results are reported. The QC requirements are specified and strict chain-of-custody protocols followed within the laboratory. Where CLP methods were not available, other approved methods were used. Table 2.4-1 shows the analytical methods used for water and soil/sediment samples.

Contract Required Quantitation Limits (CRQLs) for each of the CLP Target List Compounds and other miscellaneous parameters were presented in the Sampling and Analysis Plan (IT, 1988b). Specific detection limits are highly matrix-dependent and the CRQLs may not always be achievable. Background contamination, or concentrations of compounds other than the analytes of interest may mask the concentrations of target compounds. Dilutions must be performed that will proportionally raise the detection limits for all target compounds in that particular fraction. Similarly, samples may contain a high concentration of analytes of interest. The CLP requires sample dilution sufficient to quantify the compound with the highest concentration. This results in elevated detection limits for all compounds in that fraction.

Additional reporting requirement of the CLP includes designation of those samples containing various contaminants associated with laboratory method blanks. The method blank is used to assess the amount of contamination present within laboratory systems. It consists of a volume of deionized water or pur-

ified solid matrix carried through the entire analytical scheme. As specified in the CLP Statement of Work (EPA, 1988a, 1988b) an acceptable laboratory method blank for volatile analysis must contain less than or equal to five times the CRQL of methylene chloride, acetone, toluene, and 2-butanone, common contaminants found in laboratories that perform EPA methods of organic analyses (e.g., EPA methods 8270, 625, 1625, and 608). For all other compounds, the method blank must contain less than or equal to the CRQL of any single analyte with the exception of the common phthalate esters. If the method blank contamination exceeds the designated limits, the analyst is required to halt analyses and determine and correct the source of system contamination before sample analysis is resumed. The laboratory is also required to report all sample concentration data as uncorrected for blanks.

3.0 STATION OVERVIEW

3.1 TOPOGRAPHY AND PHYSIOGRAPHY

NAS Moffett Field is located on the southwest edge of San Francisco Bay and is situated on nearly flat interfluvial basin deposits of recent age. Elevations at NAS Moffett Field range from about 36 feet above mean sea level to 2 feet below mean sea level.

San Francisco Bay, California's largest estuary, lies in the southern portion of a structural trough formed predominantly by Pliocene tectonics. The San Pablo Bay lies within the northern end of the structural trough north of Richmond. Seawater enters the Bay through the Golden Gate and freshwater enters through numerous rivers and estuarine systems. The main river at the south end of the Bay is the Coyote River, northeast of Moffett Field. The major rivers to the north flow to San Pablo Bay and include the Napa and Russian Rivers and the Sacramento and San Joaquin Rivers which merge at the Carquinez Straits. An enormous amount of sediment has been deposited on the bay floor. Great expanses of mud flats and marsh transition to permanent water (Bakker, 1971), along the southern edge of the Bay.

Historically, tidal salt marsh and mudflat covered extensive areas of the southern portion of the Bay. Most of the marshes and mudflats in the southern portion of the Bay have been eliminated or greatly altered by diking and filling. The area just north of NAS Moffett Field is within the historic margin of San Francisco Bay and was once open to tidal action. The area northeast of the base is now bordered by commercial salt evaporator ponds and dikes, and regular tidal action has been eliminated. Minor tidal action is present at the Jagel and Guadalupe Sloughs.

Intermittent-flowing Stevens Creek borders the facility on the west, and receives only minor runoff from NAS Moffett field. Most of the runoff is diverted into a receptor ditch along the north boundary. Water collected in a sump at the downstream end of this receptor ditch is pumped to an offsite canal which drains into Guadalupe Slough and then to the Bay.

The northern half of NAS Moffett Field lies in a flood-prone area (Figure 3.1-1) that is subject to flooding only during exceptionally high tide. Low, undrained areas of the facility are subject to periodic water ponding from precipitation events.

3.2 SOILS

3.2.1 Soil Types

The U.S. Soil Conservation Service (1967 and 1968) has identified two different soil associations on NAS Moffett Field: the Reyes-Alviso Association and the Sunnyvale-Castro Association. Figure 3.2-1 depicts the location of the soil associations in and around NAS Moffett Field. The Reyes-Alviso Association consists of very poorly drained, fine-textured soils developed in gleyed, fine-textured alluvium; the association occupies the level tidal flats of the Bay. The Alviso soils constitute about 85 percent of the association and are dark grey to grey silty clay subsoils. Underlying alluvium is stratified with thin, discontinuous lenses of organic matter.

The Sunnyvale-Castro Association consists of poorly drained, fine-textured soils developed on gleyed, noncalcareous, fine-textured alluvium. The association occupies nearly level topographically low positions of interfluvial basin deposits. These soils are very deep, slowly permeable, and are saturated at depth. Sunnyvale soils, which constitute about 50 percent of the association, have calcareous, dark grey, granular, silty clay surface soils and have strongly calcareous, grey silty clay subsoils. Castro soils, which make up about 35 percent of the association, have very dark grey, calcareous, clay surface layers and grey, partially lime-cemented clay subsoils. Underlying alluvium is gleyed, noncalcareous, and fine grained.

3.2.2 Soil Composition

The composition of soils in the Santa Clara Valley is a function of the source rocks surrounding the depositional basin, and paleoenvironmental and paleoclimatological factors. Source rocks for the sediments in the valley are predominantly the Jura-Cretaceous Franciscan Formation and other Mesozoic volcanic rocks in the Santa Cruz Mountains to the southwest. The Franciscan Formation in this area includes sandstones (graywackes), cherts, blueschists,

and other metamorphic rocks. The volcanic rocks in the area include basalts, pillow lavas, and diabase rocks as well as rhyolitic and andesitic flows. The composition of the source rocks ranges from ultramafic (rocks rich in dark, ferromagnesian minerals) to silicic or felsic (rocks rich in light, alumina and silica minerals).

The environment of deposition for the sediments at Moffett Field is considered estuarine to open bay. These environments include marsh and lagoon which generally result in deposits rich in organic material. Local background levels for metals as reported by Harding Lawson (1987b), and more generic bay area background levels suggested by the USGS (1984) are listed in Table 3.2.1. The MEW RI (HLA, 1987b) background sample sites are the Mountain View Well 18 area (MV18) and the Hetch-Hetchy Aqueduct right-of-way between Whisman Road and Tyrella Avenue. Hetch-Hetchy Aqueduct samples were collected from surface to 6 inches below surface. The MV18 and Hetch-Hetchy data is from two composite samples which were made up from four subsamples taken from each sampling site.

Because the depositional environment at NAS Moffett Field is unique in comparison to general soil properties suggested by others, typical soil chemical properties were generated from this study's data set based on actual site analyses. All soils analyses were grouped into 1-, 3-, 5-, and >5-foot intervals and means, medians, and standard deviations were derived.

The total station-wide database may be divided into 149 observations at the 1-foot depth, 102 at the 3-foot depth, 103 at the 5-foot depth, and 14 at the greater than 5-foot depth. These represent the maximum potential number of observations for a given chemical. Duplicate samples and values below the detection limits were not included in the statistical calculations. For purposes of developing a typical range of chemical concentrations in site soils, the lowest (most restrictive) mean value of the four data subsets was chosen to represent ambient levels in soil at the facility which contain a given chemical. Several soil types are present at NAS Moffett Field and as such the typical range developed depicts normal chemical concentrations for those soil types which contain a specific chemical. Finally, a normal range was then chosen as plus or minus one standard deviation from the selected

mean. A generalization is made that over a large sampling of independent events (>368 observations), outliers will be found in the tails (upper bound is relevant here) of any given distribution. Intuitively, soils exhibiting potential contamination lie outside one standard deviation. Results of these analyses are presented in Table 3.2-1.

Harding Lawson (1987b) also report background data for select metals from another study about 2.5 miles east of the MEW area (Wahler Assoc., 1984). These data were collected for a soils investigation which had potential lead contamination and reflect the range of lead concentrations for that location.

The USGS (1984) soil data is from a study of surface soils throughout the United States. The study included one sample station in the Santa Clara Valley close to the NAS Moffett Field, and a second sample from the South San Francisco area. Samples for this study were collected eight inches below the surface from "materials that were very little altered from their natural conditions." The full study was based on analysis of between 1,193 and 1,319 samples for all metals of concern to the NAS Moffett Field investigation with one known exception; antimony was tested for in only 354 samples. The USGS study also had limited data on three other elements of concern to the NAS Moffett Field investigation, though the number of samples tested for these metals is not specified. Cadmium was not detected enough times to generate a valuable mean and the range presented in Table 3.2-1 is from four samples collected in California. Silver was not detected in any samples collected in California. The range for silver presented in Table 3.2-1 is from five samples collected from the western United States. The method detection limit for thallium in the USGS study was 50 ppm, which is significantly greater than the levels found at NAS Moffett Field (0.21 to 0.66 ppm).

3.3 LOCAL ALLUVIAL GEOLOGY

Local geology is dominated by Pleistocene and Holocene events. The area underlying NAS Moffett Field marks the interfingering between alluvial and estuarine depositional environments. Holocene age alluvial-fluvial sediments are coarse to fine grained and are derived from the Santa Cruz highlands, southwest of the station. The resultant gently sloping alluvial fans merged with basin, tidal, and shallow marine deposits of the baylands, which fringe

southern San Francisco Bay, to form sequences of Holocene and Pleistocene age deposits (Iwamura, 1980).

Surface geologic maps of Iwamura (1980, modified from Helly and Brabb, 1971; Figure 3.3-1) show alluvial fan deposits extend basinward approximately to Highway 101. North of 101, interfluvial finer grained deposits predominate, with the Bay fringed by Quaternary Older Bay Mud (Qobm). The southward change in units near Highway 101 from finer interfluvial deposits to coarser fan sediments is approximately coincident with a steepening of the current topographic slope towards the highlands (see Figure 3.1-1). This topographic profile is typical of bayland and alluvial fan systems. The total thickness of the alluvial material was not penetrated at NAS Moffett Field (wells to 1,000 foot), but is assumed to be greater than 1,500 feet (Iwamura, 1980).

Within the alluvial fan system, steeper fluvial gradients result in coarser, more permeable deposits. Finer sediments are deposited in the shallow gradient baylands. The resulting aquifers in the bayland, or interior basin, are stratified within predominantly clayey sections. Aquifers along the basin edges within the elevated fan system, where aquitards are limited in extent, are more extensive and interconnected. In this elevated fan area, ground water occurs as one common unconfined ground water body (Iwamura, 1980). Basinward, progressively more extensive clay units divide the aquifers. On a regional scale, Iwamura divided the section into a lower aquifer which is confined, and an upper aquifer which occurs under confined and unconfined conditions. The lower aquifer is below an extensive clay at depths of 150 to 250 feet below land surface (bls) in the mid- to lower-fan area, and from 110 to 160 feet bls in the baylands area.

Geophysical logs were used to construct geologic cross sections on the east and west side of NAS Moffett Field. One of the sections was extended regionally to include the MEW company area across Highway 101. These cross sections, A-A', B-B', C-C', and D-D', (Figures 3.3-2,-3,-4,-5) show the changing depositional conditions and resulting stratigraphy for the upper 250 feet of section. Cross-section B-B' (Figure 3.3-3) extends from Site 8 near the north end of Moffett Field through Site 9 to the south end of the base. It indicates the presence of subtidal, tidal channel, and estuarine depositional

environments. The spatial relations of these deposits show a transgressive marine system followed by progradation of an estuarine system and the fluvial system as discussed by Iwamura (1980).

Estuarine Deposition

Estuarine systems deposit coarser sediments near the estuary inlet and progressively finer sediments in the "up-estuary" direction. In a seaward progradation of an estuarine system or shoaling, the vertical sequence then also shows fining upward. The general sequence of a prograding system from the base up is (Weimer, et al., 1981; Reading, 1980):

- Coarse shelf sands or bar sands overlain by
- Coarser subtidal channel sands with gravel overlain by
- Tidal channel sands overlain by
- Tidal flat sands and muds and finally
- Organic-rich supratidal mud flats (marsh environment).

Where progradation continues in a depositional basin, fluvial systems overlie the estuarine environments. The resulting sequence shows a return to coarser deposits as the deltaic deposits change to braided stream, alluvial fan outwash, and then alluvial fan deposits. A prograding estuarine system is shown diagrammatically on Figure 3.3-6.

In the NAS Moffett Field area and south across Highway 101, the geologic section A-A' shows coarse grain sand deposits from subtidal channels or sand bars overlain by a thick clay that is regionally extensive (Figure 3.3-2). This extensive clay represents the deeper water deposition which occurred during a high sea level stand. Shoaling is seen as the coarser distal end of the estuarine system overlays the thick clay, and then grades to the finer interlayered sands and muds of tidal flat deposition. Towards the southern end of the base and across the highway in the MEW study area, the section becomes more coarse, indicating a change to fluvial or alluvial fan outwash-plain deposition. On cross-section C-C' (Figure 3.3-4) the coarse subtidal bar or channel sands are manifest as the blocky sands as shown in logs from GB-25 and GB-26 at depths from 170 to 230 feet bls. The thick clay is seen in the cross section at depths of approximately 115 to 170 feet bls. Pronounced sands occur above the clay in GB-25 and GB-26 indicating the return to sub-

tidal channel or bar sands. Thinner sand lenses interfingered with silts and clays represent tidal channel sands. In the logs of GB-7, GB-9 and GB-12, units of interbedded thin sands and clay lie above the thicker, blockier tidal channel sands (30 to 70 feet bls). The interbedded sand and clay section indicates tidal flat deposition. Towards the shoreward end of cross section B-B' (Figure 3.3-3), the resistivity log of GB-28 shows a laterally discontinuous sand at approximately 20 feet bls. Boring log descriptions of lithology in the area show inclusions of wood fragments in sands, and organic rich clays at this upper level. These data indicate deposition by fluvial channels (blocky, flat based sand) and supratidal mud flats (organic rich clay).

In general then, in an upward diagonal from the basinward (north) end of cross-section C-C' (Figure 3.3-4) to the shoreward end (south), two fining upward sequences are seen representing a transgressive marine sequence followed by a prograding estuarine sequence. This transgressive, progradational sequence can be seen in vertical section in the logs of GB-7 through GB-12 (Figures 3.3-2 through 3.3-5). Logs of GB-25 and GB-26 show the transgressive sequence followed by progradation to a tidal channel environment. Shoreward the resistivity log of GB-28 and logs of MEW wells show a sandier section, indicating progradation through the alluvial fan environment discussed by Iwamura (1980). Following the transgression, the depositional environment remains fairly stable basinward while changing rapidly shoreward. This is probably due to a combination of the prograding alluvial fans and tectonic tilting of the basin. These two conditions result in a narrowing of each microenvironment (subtidal, intertidal, supratidal) down depositional dip (north-south direction). This concept is shown by the narrowing of the high-tide/low-tide band width in Figure 3.3-7.

Quaternary Alluvium

The estuarine "bay mud" consists of unconsolidated Holocene age, and partially consolidated Pleistocene age, clay and silty clay units deposited from San Francisco Bay north of the site (Helley, et al., 1979). McCully, Frick and Gillman Inc. (1987) further defined the "bay mud" as the younger bay mud (Qybm) and the older bay mud (Qobm). A generalized local geological column is provided in Table 3.3-1 which shows units possibly penetrated by wells at NAS Moffett Field.

The Quaternary older bay mud (Qobm) lithology includes stiff, gray silty clay, sand, and gravel. The Qobm is informally subdivided into the upper (Qobm1) and the lower (Qobm2) units. The Qobm1 unit is a light-gray, silty clay and Qobm2 consists of sand and gravel containing interbedded clay, silty clay, and clayey sand (McCully, Frick and Gillman, Inc., 1987). The Qobm varies in thickness up to about 150 feet (Iwamura, 1980).

The Quaternary younger bay mud is a dark-gray to dark-brown, organic clay containing a minor amount of peat and clayey sand. The unit is an estuarine/marine silty clay that is commonly overconsolidated, stiff, semihard, and varies in thickness from 15 to 50 feet. Sand lenses occur in the younger bay mud which may be remnants of outwash deposits from nearby streams. The mineral composition of the younger bay mud and the older bay mud are similar and consists of mica, montmorillonite, chlorite, kaolinite, quartz, and feldspar (Goldman, 1969).

The basin interfluvial deposits, are predominantly coarse to fine grained alluvium. Periodic fluctuations in sea level during the Holocene have caused complicated facies relationships between the alluvial-fluvial and estuarine depositional environments. This relationship has resulted in an interbedding of fine-grained alluvial and bay mud deposits, which generally have low hydraulic conductivities (aquitards), with coarser-grained alluvial fan and fluvial deposits which can yield and transmit substantial amounts of water (aquifers).

Faulting

Two active regional faults bound the Santa Clara Valley where the station is located: The San Andreas Fault and the Hayward Fault. The nearly flat lying units of the area indicate that any movement associated with these faults has not caused significant structural deformation in the relatively shallow stratigraphic section. Similarly, the broad downwarping of the basin has not resulted in noticeable structural deformation. However, some clay units do exhibit localized fracturing with slickenside surfaces. These fractures may be due to several processes, including localized land subsidence, compaction, or Holocene faulting.

3.4 GEOHYDROLOGY

3.4.1 Regional Geohydrology

NAS Moffett Field is located in the Santa Clara Valley ground water basin, which occupies one of several large northwest-trending valleys in the Coast Ranges of California (ESA, 1986b). The Santa Clara Valley is a gently northward-sloping trough and filled with unconsolidated to semiconsolidated sediments as much as 1,500 feet thick near the center (Iwamura, 1980), then thinning to feather edges along the margins. The Santa Cruz Mountains form the western boundary of the valley and its corresponding ground water basin. The Diablo Range lies to the east. The northwestern part of the trough has been intermittently inundated by the Pacific Ocean for approximately one million years (Helley et al., 1979) to form the southern arm of San Francisco Bay. This inundation has been periodic as sea level rose and fell in response to climatic fluctuations. During warm periods, the basin was partially flooded and marine sediments accumulated in the bay. During colder, glacial periods, the sea level was lowered as much as 300 to 400 feet below its present elevation and alluvial and lacustrine sediments would slowly accumulate in the basin. The maximum average rate of alluvial deposition near Sunnyvale for example, was less than 5 inches per 1,000 years (Meade, 1967). About 10,000-11,000 years ago, the sea entered the Golden Gate once again, gradually spreading to its present elevation by 5,000-6,000 years ago.

The unconsolidated basin-fill deposits consist of interbedded layers, tongues, and lenses of gravel, sand, silt, and clay as depicted on Figure 3.4-1. The coarser-grained sands and gravels that readily transmit ground water (aquifers) were deposited on the flood plains of streams, and in estuarine channels by relatively fast-moving water. The finer-grained clays and silts that restrain or restrict ground water flow (aquitards) were deposited in slow-moving or still water in the open bay as well as in relatively flat estuarine and interfluvial marsh areas. Individual beds generally are thin and of limited areal extent as a result of lateral shifts of channels on the alluvial fans and in estuaries along the margins of the bay. Major transgressions of the San Francisco Bay resulted in more regionally extensive fine grained deposits.

3.4.2 Local Geohydrology

The geohydrologic setting in the vicinity of NAS Moffett Field consists of alluvial sand aquifers or sand and gravel aquifers separated by low permeability silts and clays. In the interior part of the Santa Clara Valley, the numerous aquifers have been divided by Iwamura (1980) into two broad zones or sequences: the upper-aquifer sequence and the lower-aquifer sequence. The distinction between the two aquifer sequences is that the lower-aquifer sequence is semiconfined under a laterally extensive clay aquitard at depths of 140 to 200 feet bls and the upper-aquifer zone is generally unconfined, although in places it acts as semiconfined.

An alphanumeric subaquifer-aquifer nomenclature was introduced by Harding Lawson (HLA, 1987) during their studies for the MEW companies. The basic nomenclature has been retained and refined to adequately describe the local geohydrologic environment. The upper aquifer zone contains two definable aquifers; A and B. Within the B aquifer Harding Lawson (1987b) identified three discrete subaquifers, B1, B2, and B3, residing from highest to lowest in relative elevations respectively. In this study, the A aquifer is partitioned into an A1 and A2 component, again from highest to lowest relative elevations. The lower aquifer sequence is denoted as C by Harding Lawson (1987b). The C aquifer was not subdivided by the earlier investigations. It is known that the C aquifer does in fact contain many alternating coarse and fine grained layers and extends over 1,000 feet in depth. The following discussion presents the current state of knowledge with regard to subsurface water flow beneath NAS Moffett Field. As studies proceed it is expected that a more complete interpretation will be developed. Discussion is skewed towards the upper aquifer sequence as it represents the water bearing units of greatest interest at this junction of the study.

Shallow Aquifer Sequence

Aquifers in the upper zone (A and B) are generally thin and discontinuous. Aquifer materials range from silty sand to fine-to-coarse gravel. The A and the B aquifers are not presently pumped for beneficial uses. In most places on the station the water from these aquifers is brackish.

The uppermost aquifer (A) primarily lies between 10 and 70 feet bls. Ground water lenses in the A aquifer may be divided into two distinct but discontinuous subaquifers. Previous investigators have identified these thin, 3- to 20-foot thick subaquifers, as the A and B1 (HLA, 1987b) and the "20 foot" and "45 foot" aquifers (Iwamura, 1980) respectively. After careful review of lithologic data collected to date, it appears that on the station the B1 or "45 foot" aquifer is part of the A aquifer. This interpretation is based on the similarity of lithologic, sedimentologic, and hydrologic characteristics of the A and B1 aquifer materials and is likely a result of lateral changes (facies changes) in the aquifer material and the dividing aquitards. Therefore, where two permeable components exist within the uppermost 70 feet from land surface the A aquifer is subdivided into an A1 and A2 component. (See Figures 3.3-3 through 6) Water level measurements made in this study support the contention that these aquifers are hydraulically interconnected in places and separate in other locations. Hydraulic characteristics of the A1 and A2 subaquifers vary but are prominently unique on NAS Moffett Field.

Previous investigations (HLA, 1987b, Canonie, 1987, Iwamura, 1980) have developed their interpretations of subsurface lithology based on references to local land surface. The vertical distribution of aquifers as defined by this study and previous work is shown on Table 3.4-1.

As mentioned earlier, the B aquifer sequence underlies the A aquifer sequence and was divided into the B1, B2, and B3 subaquifers by Harding Lawson (1987b). Continuing work on NAS Moffett Field suggests that the B1 aquifer unit has geologic and hydrologic characteristics similar to the A1 on the station. This interpretation is based on extensive reviews of local and regional cross-sections as discussed in Section 3.3. The B1 aquifer as defined by Harding Lawson (1987a) has been designated the A2 aquifer, with the aquitard at about 45 to 60 feet bls. The B2 aquifer beneath the station ranges from about 60 to 105 feet bls and the B3 from 110 to 125 feet bls. In addition, a thin, but locally continuous aquifer was identified from geophysical logs and well data from 155 to 175 feet bls. The base of this aquifer is typically 5 to 10 feet above the main sand unit considered the C aquifer, and it has been interpreted as part of the C aquifer.

Geologic and geophysical investigations at the MEW site (HLA, 1987a) indicate that the shallow interbedded alluvial deposits dip towards the north at about 0.5 degree (1.1 percent grade) with the deeper units being approximately horizontal.

Lower Aquifer Sequence

The aquitard between the B- and C-Aquifer zones is the most laterally extensive and correlatable unit in the area and is generally recognized to be the division between Iwamura's (1980) upper and lower aquifers. The presently recognized typical depths and thickness of the hydrogeologic units at the MEW site are presented in Table 3.4.-1. The "lower" aquifer primarily lies between 200 and >500 feet bls. Ground water producing material is generally thin (3 to 13 feet), discontinuous and consists of silty sand to fine-to-coarse gravel. The aquitard material is generally 20 to about 100 feet thick and consists of blue and yellow clay (Navy Department, Bureau of Yards and Docks, Drawing 112,977, January 27, 1932). The extensive amount of aquitard material and compaction due to loading contribute to the flowing artisan condition of the aquifer. Wells that were used for water supplies at NAS Moffett Field were drilled to a total depth of 1,000 feet bls.

The C Aquifer represents the primary source of ground water in and around NAS Moffett Field. In addition to current agricultural use and historic drinking water use at NAS Moffett Field, the water is used for public drinking water and commercial, agricultural, and industrial purposes in the surrounding communities.

Ground Water Hydraulics

Recharge to the shallow aquifer zone is primarily from infiltration on upgradient coarse grained deposits by percolation of rainfall, stream flow, and excess irrigation water. Recharge to the confined aquifer in the deep aquifer zone is the result of downward percolation occurring on alluvial fans at the base of the Santa Cruz Mountains. Also, recharge to the lower aquifer zone occurs from rainfall, stream flow, and excess irrigation water on upgradient alluvial fans. The relationship of aquifers in the vicinity of NAS Moffett Field is shown in Figure 3.4-1.

Excessive pumping of ground water from the C Aquifer has resulted in land subsidence and sea water intrusion into the aquifer. An artificial recharge program and ground water withdrawal management program conducted by the Santa Clara Valley Water District has curtailed the land subsidence and sea water intrusion. Uses of the ground water at NAS Moffett Field are now limited only to agricultural needs. Land subsidence in the NAS Moffett Field area ranges from 2 feet in the north to 8 feet in the southeast part of the base.

The maximum hydraulic gradient (in the A1 aquifer) is estimated to be about 19 feet per mile (0.0036 feet/ foot). The average hydraulic conductivity in the A1, A2, and B2 aquifers, based on limited pumping test data (EMCON, 1983a), is about 8×10^{-3} cm/s. The porosity of aquifer materials (silty sands) typically ranges from 0.25 to 0.5 (Freeze and Cherry, 1979). Potential lateral ground water movement in the aquifers of silty sand to clean sand is on the order of 0.3 to 30.0 feet per day, based on average hydraulic conductivity values of these materials. Due to the discontinuous fashion in which sediments were deposited and to the highly variable organic content, values of hydraulic coefficients may vary over several orders of magnitude. Physical properties specific to NAS Moffett Field geologic materials were limited to aquitard materials during this study, and are discussed in Section 4.0.

3.5 GENERAL WATER QUALITY

3.5.1 Regional Water Quality

The general quality of ground water is the result of water infiltrating along the surface. As the water infiltrates into the ground and percolates downward, the characteristics of the water change. Total dissolved solid content increases with depth and generally ranges from 66 to 20,000 mg/l. The calcium content of the water also increases causing the water to become "harder". Because of the chemical make-up of the calcareous soils of the alluvial fan area, water in the Santa Clara Valley tends to be a calcium-magnesium bicarbonate type. Most waters in the A aquifer contain predominately calcium-magnesium bicarbonate. The major fraction in water from the B and C aquifers tends to be sodium bicarbonate. Water in the B and C aquifers also exhibit low levels of chloride, 50 mg/l or less. Regional water quality data obtained from the California Department of Water Resources is presented in Table 3.5-1.

A chemical distinction exists among the A, B, and C aquifers where extensive irrigation has also increased the salt content of the water. Degradation of the shallow ground water as a result of agricultural wastewater, or excessive amounts of water being applied to the crops, has increased the salt content. Additionally, salt water intrusion has occurred in the A, B and C aquifers (upper and lower aquifer zones of Iwamura). Concentrations of chloride in water from the A and B aquifers range from less than 100 mg/l in the south to greater than 5,000 mg/l in the north part of NAS Moffett Field. Salt water intrusion in the C aquifer is not extensive, and chloride concentrations exceed 100 mg/l only in the north part of the station. Harding Lawson Associates conducted a sampling program (HLA, 1987a) which showed that chloride levels tend to decrease with depth. This trend is not consistent with total dissolved solids (TDS). The C aquifer contains higher levels of TDS than the B aquifer as the result of longer residence time of water in the C aquifer. This phenomena is consistent with the general theory of ground water evolution which states that, as ground water moves deeper through an aquifer it interacts with aquifer material which tends to increase the concentration of dissolved minerals. Results from the Harding Lawson (1987a) study also indicate that in the vicinity of NAS Moffett Field approximately one half of all wells in the A and B aquifers contain measurable levels of total coliform bacteria.

3.5.2 Local Water Quality

NAS Moffett Field is located less than one mile from the San Francisco Bay and is directly adjacent to the Leslie Salt Company evaporation ponds. Regional saltwater intrusion has been documented by Iwamura (1980) as discussed in the previous section. Saltwater intrusion has resulted in chloride concentrations ranging from about 5,000 mg/l at the north end of the station to 100 mg/l at the south end. The saltwater intrusion is also evident by elevated concentrations of other common seawater metals and cations such as calcium, sodium, magnesium, potassium and sulfate. Additionally, seawater commonly contains significant concentrations of many trace elements including arsenic, copper, cadmium, lead, mercury, silver, and zinc (Table 3.5-2). The NAS Moffett Field wells show the highest concentrations of both major and minor elements near the evaporation ponds and a decrease in concentrations to the south.

Regional water quality data from the California Department of Water Resources for the Santa Clara Hydrologic unit are presented in Table 3.5-1. Data from monitoring well W10-6(C) are also shown in this table. This well was installed in the Phase I investigation in a location upgradient of all known potential source areas on the station. The C aquifer has not shown any organic contamination in the vicinity. Because NAS Moffett Field is within the area of saltwater intrusion, and has higher concentrations of common seawater cations and trace metals, a comparison to regional background data and deep aquifer data is difficult. Currently, only limited data are available to establish meaningful background concentrations for inorganics in ground water in the area.

3.6 BIOTA

3.6.1 Vegetation

NAS Moffett Field is situated on a gently sloping tidal basin area of old mud flats once covered extensively by tidal marsh plants. This scene is still typical of some of the areas north of the station; however, diking, construction of salt evaporation ponds, and filling activities have considerably decreased the marsh habitat and has limited it to narrow buffer zones along the fringes of sloughs. Typically, cordgrass resides in the low tidal zones and gives way to pickleweed, salt grass, and other salt-tolerant plants on drier sites. This vegetation occurs mainly along Stevens Creek and Guadalupe Slough. The brackish water marsh vegetation occurs abundantly along the northern portion of the station, and where salt concentrations are low the vegetation gives way to cattails and sedges. Where salt concentrations are low and sites are relatively dry, opportunistic (ruderal) vegetation invades. Common plants which occur on these sites are cranesbill, sweet clover, vetch, mustard, thistle, and sweet fennel along with a variety of grasses.

3.6.2 Wildlife

The tidal marsh areas provide critical habitat for the production of fish and shellfish, and especially the lower food chain organisms such as zooplankton, brine shrimp, and bottom dwelling (benthic) organisms. As a result, this

habitat is utilized by a variety of mammals and birds including migratory birds on the Pacific Flyway.

Typical marsh habitat shorebirds include the black-necked stilt, killdeer, sandpiper, great blue heron, great egret, and the American coot. A variety of ducks, gulls, and terns inhabit the marsh and salt evaporation ponds. The ruderal vegetation provides habitat for a multitude of sparrows, finches, meadowlarks, and mourning doves. Burrowing owls and ring-neck pheasant also occur in the vicinity of NAS Moffett Field (WESTDIV, 1985; IT, 1988a).

Mammals on site include the common California ground squirrel, grey fox, black-tailed hare, striped skunk, California vole, and feral cat.

Sea life includes harbor seals, occasional steelhead trout, jacksmelt, sturgeon, sharks, rays, striped bass, and bait fish. These include shiner perch, gobies, long-jaw mudsuckers, and crangon shrimp.

3.6.3 Endangered, Threatened, and Rare Species

Federal agencies are required to carry out their programs to ensure that the existence of any endangered or threatened species is not jeopardized and that the habitat of these species is not adversely modified or destroyed.

The national list of endangered and threatened animal and plant species is published in the Code of Federal Regulations (CFR) at 50 CFR 17.11 (animals) and 17.12 (plants). The California state animal list is provided in the California Code of Regulations (CCR), Title 14, Section 670.5. The list of rare endangered plant species is published by the California Native Plant Society in its "Inventory of Rare and Endangered Vascular Plants of California." The following endangered, threatened, or rare species may inhabit the NAS Moffett Field vicinity:

- Animals - California least tern; California clapper rail; California black rail; Brown pelican; and the salt marsh harvest mouse.
- Plant - Marsh gum plant.

4.0 RUNWAY LANDFILL - SITE 1

4.1 DESCRIPTION AND HISTORY

The Runway Landfill is located at the northeast end of NAS Moffett Field and lies at the end of the runways between Zook Road and the Leslie Salt Company evaporation ponds. It is within the boundary of the City of Sunnyvale. Earthen fill and refuse have been placed at the site which extends to depths of 2 to 13 feet below sea level. Although the landfill was abandoned in the late 70s, it was never formally closed. The location of the site is shown on Figure 4.1-1.

The landfill was used for disposal of refuse, scrap equipment, and hazardous materials from the early 1960s to 1978. Disposed materials included paint and thinners, solvents, lacquer, oil, fuel filters, and sawdust contaminated with transformer oils (possibly containing PCBs).

Site 1 was originally marshland which was flood-prone during high tides. Although the area was diked in 1960 as part of the runway construction, flooding and seawater intrusion continued because of land subsidence resulting from the regional pumping of ground water. Since early 1970, ground water management has prevented additional subsidence, allowing additional diking to be effective in preventing flooding. The area is presently used for storage of traffic control materials and a pistol practice range. The adjacent Leslie Salt Company salt evaporation ponds are the nearest commercial activity.

Stereo aerial photographs taken in 1963 showed a trench cut into marsh which was approximately 5,000 feet long and 100 feet wide. The trench ran east-west and extended from Jagel Slough to the runway extension. Aerial photos taken in 1967 indicated that the trench had been filled, presumably with landfill material. The original purpose of the trench has not been determined.

Information obtained from early sources indicated that the refuse fill was placed in an excavation that ranged in depth from 2 feet to over 12 feet below mean sea level (MSL). The waste materials were placed above the land surface to elevations up to 10 feet above MSL. The landfill was then covered with soil that ranged from 0.6 to 7 feet in thickness. The cover material appeared

to be gravelly sand on the eastern portion of the landfill and organic silt on the western portion of the landfill.

Deposition records are not available for the landfill. All information related to types and quantities of waste disposed at the landfill were obtained by personal communications with current or previous staff at NAS Moffett Field (NEESA, 1984). In addition to accepting refuse, debris, and scrap equipment, waste from a variety of shops was also disposed at the landfill. The following is an estimate of the amounts of hazardous waste material disposed at the landfill:

- TCE, toluene, MEK, and other materials including:
 - Stoddard Solvent 110,000 gallons
 - Ash 368,000 pounds
 - Asbestos 16,000 pounds
 - Paint, lacquer, and thinners 24,000 gallons
 - Jet (JP) fuels 51,000 gallons
 - Waste oil (in 55 gallon drums) 3,300 gallons
 - Used lubricant oil 12,000 gallons
 - Fuel filters (containing fuel sludge, lead compounds, and rust) 19,000 each
 - Transformer oil 1,260 gallons
 - Transformer filters 580 each
 - Transformer oil contaminated sawdust unknown amount

Although there are no records about disposal at the landfill, it is believed that the total amount of liquid and solid waste is about 200,000 gallons and at least 390,000 pounds, respectively.

4.2 FIELD INVESTIGATION

The objectives of the investigation at Site 1 were to define the geologic and hydrogeologic conditions near the landfill and to investigate the existence and distribution of subsurface contaminants associated with the runway landfill. Major field activities conducted during the course of this study included:

- Surface geophysical surveying
- Continuous coring and geophysical logging from borings around the periphery of the landfill

- Installation of monitoring wells within and around the periphery of the landfill
- Laboratory testing of permeability and porosity in fine grained soils from beneath and surrounding the landfill
- Collection of surface water and sediment samples
- Collection of ground water samples from newly installed wells.

A Solid Waste Assessment Test (SWAT) report concerning the water resources at Sites 1 and 2 has been previously published (IT, 1988c). The SWAT report includes summaries of the site characteristics (geology, hydrology, and land and water use), site history (landfill operation and waste characterization), the SWAT investigation summary, analytical results, and conclusions.

In addition to the SWAT Report required for the two inactive landfills at NAS Moffett Field, a screening questionnaire for air testing was submitted for each landfill to the Bay Area Air Quality Management District (BAAQMD) (IT, 1988c, 1988d). The requirements for testing are based on the proximity of the site to residences, schools, and other sensitive areas. The District reviewed the questionnaire and determined that gas stream characterization and gas migration testing are required for both the Runway Landfill (Site 1) and the Golf Course Landfill (Site 2). Air quality testing has not yet been initiated at Sites 1 and 2.

The subsurface geophysical survey, geophysical borings, leachate wells, and ground water monitoring wells planned for the investigation have been completed. Summary description of activities is given here and additional details are provided in various quarterly reports identified in the following subsections. Interpretations and discussions of study results are discussed in Section 4.4.

4.2.1 Surface Geophysical Surveys

Geophysical surveys consisted of terrain conductivity measurements and vertical electric soundings to estimate the lateral extent and thickness of the landfill. The contrast in conductivity between the native material and fill material provided an approximation of the landfill limits. The survey confirmed that the area of the fill can be defined by the elevated terrain.

Electrical resistivity was used to define the thickness of the fill (0 to 34 feet) and also defined the location of a buried trench, which had been previously identified by historical aerial photographs. Figure 4.2-1 identifies the buried trench and the approximate outline of the Site 1 landfill boundary.

Electromagnetic induction methods of conductivity measurements were used to measure terrain conductivities along 11 traverse lines which ranged in length from 300 feet to 1,050 feet. The total lineal coverage was 7,300 feet. In addition, 19 vertical electric soundings were performed. The locations of the terrain conductivity profiles and vertical electric soundings are shown on Figure 4.2-2. Figure 4.2-3 shows the distribution of terrain conductivities across the site. Areas of low conductivity, <200 milli-siemens per meter (mS/m), indicate areas of possible fill material; areas of high conductivity, >325 mS/m, represent native soils such as clay and silt. Geoelectric cross sections, Figure 4.2-4, depict the variation of electrical resistivity with depth. The diagrammatic sketches illustrate the boundary between landfill material and native soil. Features such as the trench identified by aerial photography can be seen on the illustrations.

4.2.2 Geophysical Borings

Three geophysical borings - GB-4, GB-5, and GB-6 - were drilled around the periphery of the landfill prior to the installation of aquifer monitoring wells. The borings were continuously cored and geophysically logged. The locations of these borings are shown in Figure 4.2-5. Geophysical Boring GB-4 bottomed at 212 feet, GB-5 at 253 feet, and GB-6 at 153 feet. Downhole geophysical electric logs included point resistivity, spontaneous potential, and natural gamma. Caliper logging of the borehole size was also conducted. Figure 4.2-6 represents the geologic interpretation from these borings.

4.2.3 Ground Water Monitoring Wells

Nine monitoring wells were installed during this study. Wells were designed either to monitor leachate within the landfill or ground water in the shallowest (A) aquifer beneath and surrounding the landfill. Four leachate wells and five A aquifer monitoring wells were installed. Figure 4.2-5 shows the areal distribution of the wells. Leachate wells range in total drilled depth from 19 to 44 feet and were screened at varying intervals from about 7 to 29

feet. The wells were designed to monitor ground water as it moves through the waste fill material. Aquifer monitoring wells varying in total drilled depth from 15 to 75 feet and screened at varying intervals from 12.5 to 70 feet, were used to monitor ground water as it moves beneath the base of the landfill. The discrepancy between total drilled depth and screened depth is due to overdrilling select boreholes which were subsequently backfilled with clay and screened at shallower depths. Well completion details are summarized in Table 2.3-2. W01-06(A2) is located in what was a presumed upgradient position. However, all A aquifer monitoring wells are downgradient because of the effects on flow due to the local pumping station. This phenomenon is discussed further in Section 4.3.

4.2.4 Soil Borings

Three soil borings were drilled at Site 1 for geophysical information and soil characterization. Additionally, six embankment samples were taken to determine the composition of the landfill embankment.

Two soil borings, SB1-1 and SB1-2, were drilled to determine the depth of fill material at specific locations. These borings were drilled for physical characterization purposes only and no samples for chemical analysis were taken.

SB1-1 encountered silty clay at 20 feet below land surface and was completed at a total depth of 25 feet. Soil boring SB1-2 encountered methane gas at 15 feet and was abandoned at 26.5 feet because of lack of recovery. Only fill material was recovered from the boring.

Four embankment samples (EMB 1 through 4) were collected by removing 1 foot of top soil and using a 2-inch diameter sample tube to collect a 1-foot sample. Two samples, EMB-5 and EMB-6, were collected from 3 feet bls and were sent to a geotechnical laboratory for the determination of effective porosity and hydraulic conductivity. The remaining four samples were sent to the analytical laboratory for chemical analysis. Figure 4.2-5 shows the location of the EMB samples.

4.2.5 Laboratory Physical Parameters

Laboratory permeability and effective porosity tests were conducted on samples from each of the nine monitoring well borings and two landfill embankment samples. Samples were collected from the clay zone above the anticipated aquifer zone in the ground water monitoring well borings, and from the clay at total depth below the landfill material in the leachate well borings. A total of 12 laboratory tests were performed for Site 1 samples. The tested intervals and results are discussed in Section 4.3.

4.2.6 Soil Samples

Soil samples were collected from all monitoring well borings for chemical analysis. Samples were collected from 1-, 3-, 5-, and 10-foot depths (or at the water table). Also, one soil sample was collected from the native soil at the bottom of each leachate well boring to assess vertical migration of contaminants beneath the landfill. A total of 45 soil samples were collected for chemical analysis. As mentioned earlier, four shallow soil embankment samples were collected for chemical analysis.

Soil samples were analyzed for VOCs, priority pollutant metals, pH, PCBs, and base/neutral and acid extractables (BNAs). Preliminary analytical results are summarized in the December 1988 Quarterly Report (IT, 1988e) and data summary tables are provided in Appendix A. An interpretation of soils data follows in Section 4.4.

4.2.7 Ground Water Samples

Ground water and leachate samples were analyzed for VOCs, BNAs, PCBs, metals, total dissolved solids (TDS), pH, specific conductance, and major anions (bicarbonate, carbonate, calcium, chloride, magnesium, nitrate, potassium, sodium, and sulfate). A ground water summary table is included in Appendix B. Preliminary analytical results can be found in the December, 1988 (IT, 1988e) and the August, 1989 Quarterly Report (IT, 1989c). An interpretation of ground water data follows in Section 4.4.

4.2.8 Surface Water and Sediment Samples

Surface water and sediment sampling was conducted at two locations within surface water bodies that could be affected by the landfill, Jagel Slough and

the northern salt evaporation pond. These locations are identified in Figure 4.2-5. Surface water and sediment sampling were separated into wet and dry season events.

Surface water and sediment samples were analyzed for VOCs, BNAs, PCBs, metals, TDS, pH, specific conductance, and major anions. Preliminary analytical data was presented in the December 1988 (IT, 1988e) and August 1989 (IT, 1989c) quarterly reports. Summary tables are provided in Appendices C (soils) and D (water).

4.2.9 Water Level Measurements

Water level measurements were taken from landfill leachate (F) and ground water (A) monitoring wells. The A-aquifer monitoring wells include previously installed ESA wells W01-01(A1), W01-02(A1), W01-03(F), and W01-04(A1). Measurements were taken monthly from August 1988 to October 1989. Data from these wells were used to construct potentiometric surface maps of the A aquifer on a quarterly basis. These maps are presented in Appendix B. Hydrographs of the Site 1 well water levels are presented in Appendix A.

4.3 HYDROGEOLOGY

4.3.1 Site Geology

The stratigraphy of Site 1 is a complex interfingering of fine- and coarse-grained units representing the boundary between alluvial and estuarine environments and fluctuations of the boundary due to sea level changes (Figure 3.3-7). Lithologic logs from shallow well borings indicate that the uppermost materials (0-60 feet) are comprised of silts to silty clays which are brown to black, saturated and moderately plastic. Intermittent throughout the upper 60 feet are interfingered sands and gravels, which vary in composition from a silty sandy gravel to a clayey gravel. These permeable materials are medium gray to black or brown. Sand and gravel lenses or stringers seem to be areally consistent at the site; however, thicknesses vary widely from location to location. As an example, at boring W01-05(A1) the thickness of the uppermost sandy silty gravel is about 4 feet thick, whereas at boring W01-12(A1) the thickness of the gravelly sandy clay and poorly sorted sands is about 26 feet thick.

Geophysical borings and monitoring wells greater than 60 feet in depth show mostly silty clay that is interfingered with sandy clayey gravel and sand lenses. Lithologic logs also indicate variable thicknesses and limited areal extent of these lenses. The silty clay is brown to light gray, saturated, and low to moderately plastic.

Subsurface clays from A-aquifer and leachate well borings were tested for porosity and permeability by laboratory geotechnical testing methods. Samples from the leachate well borings were collected from native clays below the fill material. A-aquifer well boring samples were from the clay above the saturated zone. The sample intervals and results of testing are shown in Table 4.3-1. The results indicate that clays below the landfill and above the A aquifer generally have permeability values in the 10^{-8} cm/sec range.

4.3.2 Hydrology

Surface Water

Although there is minimal topographic relief at Site 1, surface water flow is overland and by engineered drainage channels. Surface elevations at the landfill vary from -3 feet msl to about 23 feet msl. Runoff from the mounded structure drains into a former evaporation pond to the north of the landfill. There is a small drainage ditch which runs along the east side of the mound that collects runoff and moves it to the evaporation pond. To the southeast, it appears that drainage goes to the adjacent slough which is confined within the evaporation pond dikes. Because of the high porosity of the cover material, precipitation infiltrates directly into the landfill and limits the occurrence of erosional channels. The landfill is hydrologically isolated from other sites at NAS Moffett Field and does not receive runoff from these other sites.

The movement of leachate from the landfill occurs during the rainy season. The leachate moves with the surface water to the former evaporation pond to the north of the landfill. A possible pathway for leachate movement away from the site may be beneath the runway extension via an old channel and into the adjacent marsh. Low water levels in monitoring wells near the runway exten-

sion and an excavated channel seen in historical aerial photographs tend to support this hypothesis (Figure 4.2-1). The excavated channel could be the pathway, with the low water levels indicating flow to lower elevation areas.

Vadose Zone

Because of the low topography and subsidence caused by the pumping of ground water around the site, most of the ground water levels in Site 1 monitoring wells are below sea level. The vadose zone, between the saturated zone and the land surface, consists of either saturated fill or clay which retards subsurface water flow. Because of the layering of saturated materials within waste fill, numerous small perched saturated lenses of trash have been observed. These lenses are believed to vary in thickness and areal extent, and may or may not be saturated, depending upon the season.

Ground Water

Aquifers underlying Site 1 consist of silty sand or sand and gravel deposits separated by relatively impermeable silts and clays. The sand and gravel aquifers vary in thickness and appear to be laterally discontinuous. The thickness of the water bearing units vary from 1 to 30 feet and were encountered from 7 bls to over 200 feet bls. At Site 1, the A aquifer extends from 15 bls feet to approximately 65 feet bls. Above the A aquifer is the fill aquifer which is in fill material and not related to "natural" aquifers.

The clay interval immediately below the fill material appears to be correlative with the clay above the A aquifer. This clay interval is shown on boring logs from three fill wells as:

<u>Well No.</u>	<u>Drilled Depth (feet bls)</u>	<u>Depth (feet msl)</u>
W01-09(F)	29 to 33	-12 to -16
W01-10(F)	15 to 20	- 8 to -13
W01-11(F)	26 to 30	-13 to -17

As discussed previously, laboratory geotechnical tests indicate these clays have low hydraulic conductivity values on the order of 10^{-8} cm/sec (Table 4.3-1). Hydraulic conductivity of the material beneath Site 1 was also measured in leachate wells using the slug test method. The slug test data were con-

sidered invalid due to leakage around the temporary casing used to conduct tests (IT, 1988c).

The A aquifer can be divided into two water-bearing units (A1 and A2), the A1 in the interval from about -15 to -25 feet msl and the A2 about -25 to -70 feet msl [see borings W01-05(A1) and W01-07(A2)]. Only well W01-07(A2) is screened in the A2 portion of the aquifer. Logs of well W01-12(A1) indicate that there is no aquitard between the A1 subaquifer and the A2 subaquifer at that location. The A1/A2 aquitard was present in the other eight wells and ranged from a silty clay to clay. Logs of the wells drilled at Site 1 were presented in the December 1988 Quarterly Report (IT, 1988e).

The A2 aquifer consists of silty gravelly sand grading to a clean sand. The aquitard between the A2 and B2 aquifer appears to be a clay of very low hydraulic conductivity. No aquifer tests were conducted in the Site 1 wells. Data obtained from another site at NAS Moffett Field indicated hydraulic conductivities for the A aquifer in the range of 1×10^{-5} cm/sec to 1×10^{-6} cm/sec. These values are indicative of a silt (Freeze and Cherry, 1979).

The B aquifer components B2 and B3 are composed of clayey sands and clayey gravel found at depths from 65 to 100 feet. The C aquifer is composed of clayey sandy gravels and clayey sands. The top of the C aquifer was encountered at about 140 feet bls and about 70 feet of it was penetrated by the Site 1 geophysical borings. Though individual coarse units of the B and C aquifer appear to be discontinuous, core recovery and E-log character in deep borings indicate lateral connection between water bearing zones in the Site 1 area. All monitoring wells at Site 1 are screened within the A aquifer; only geophysical borings penetrated the B and C aquifers.

Based on September 1988 data, ground water flow is outward in a radial pattern with the highest level being at the topographic high of the landfill (Figure 4.2-1). Water level elevations are not available from under the Jagel Slough or the saltwater holding/transfer ponds. The gradient is nearly flat with a slope of 0.5 foot/100 feet average. The gradients and the directions of ground water flow suggest that sea water is not readily intruding the Site 1 area. Water levels are all below sea level within the boundaries of Site 1,

and seasonal variations are limited as is illustrated by the hydrographs included in Appendix A.

4.4 NATURE AND EXTENT OF CONTAMINATION

4.4.1 Sources

The source of potential contamination to soils and ground water at Site 1 is the buried refuse in the landfill. As previously shown, the landfill received various waste solvents, refuse, and scrap equipment during the early 1960s to 1978.

Infiltration of rainwater through the cover creates a leachate which may contain some of the more mobile, water-soluble organic and inorganic constituents. Seepage of water-insoluble or hydrophobic organic compounds dissolved metals and nonmetals also constitutes a component of the leachate.

4.4.2 Review of Chemical Analyses

Chemical analyses were conducted on several types of samples collected from Site 1. The sample types include water from surface water bodies and wells, leachate from landfill wells, sediments from the bottoms of surface water bodies, soils from the landfill, and soils from borings outside the landfill. The results of the chemical analyses are discussed below and summary results tables are included in Appendices C and D of this report.

The distribution of chemical constituents detected at NAS Moffett Field are shown on station-wide base maps contained in Appendix E. Inorganic and organic constituents are shown on separate maps for soil and water. Soils data maps include samples from all borings, as well as sediment and embankment samples. Water data maps include surface water and ground water concentration ranges for organic and inorganic analytes.

Surface Water

Surface water samples were collected at two locations: Jagel Slough and the salt evaporation pond located north of Site 1. The locations are depicted in Figure 4.2-5. Wet and dry season samples were collected from Jagel Slough. Only a wet season sample was collected from the salt evaporation pond because

the area is dry in the dry season. Surface water samples were analyzed for VOCs, BNAs, metals, TDS, pH, specific conductance and major anions.

All volatile or semivolatile compounds except acetone were less than their quantitation limits, and/or associated with laboratory method blank contamination. Acetone was detected only one time without associated blank contamination noted and it was found at the quantitation limit of 10 µg/l.

Surface water analysis showed the primary seawater minerals are present in the water bodies at similar concentrations to seawater. Because these elements and ions are common to seawater, the diking of these surface water bodies may result in elevated levels of common salts due to evaporation. The slightly elevated concentrations are not considered unnatural and will not be discussed further. The elements and ions in this category are:

- Calcium
- Magnesium
- Potassium
- Sodium
- Bicarbonate
- Chloride
- Fluoride
- Sulfate.

The remaining elements were compared to ground water background levels discussed in Section 3.5 (Table 3.5-1). This background source was selected for comparison over the seawater background because the latter values are for open ocean seawater which does not have a high sediment load. The sediment load carried by bay water may result in higher dissolved solid content. Also, the enclosed water bodies may be strongly influenced by ground water and surface water infiltrating to the bay through normal hydraulic relations. Comparison to the California DWR baseline shown in Table 3.5-1 resulted in three metals above the baseline. These are discussed individually.

Arsenic was found above baseline of 10 µg/l in the one sample from the Salt Flat at 12.3 µg/l, slightly above quantitation limits. The element was also reported in the Jagel Slough samples, but at levels below quantitation limits (10 µg/l) and baseline.

Cadmium was found at 83.7 $\mu\text{g/l}$ in the wet season sample from Jagel Slough but was not detected in other samples (quantitation limit of 5 $\mu\text{g/l}$). Silver was detected at 80.6 $\mu\text{g/l}$ in a wet season sample in Jagel Slough; however, silver was not detected in the dry season sample.

Total dissolved solids concentrations in the three surface water samples were greater than 20,000 mg/l which created interference effects for detection of trace elements. Detection limits for some compounds were therefore higher than would be expected for freshwater samples.

Landfill Materials, Soils, and Sediments

Sampling of three classes of soils was performed at Site 1, including landfill solids, soils from the landfill periphery, and shallow sediment in shallow surface water features. Four borings were advanced through the waste materials into natural soils. A total of 16 samples were collected from these borings; 12 were associated with refuse and the bottom four (one from each boring) were from natural soils. Four refuse samples were also collected through the sidewall embankments. Nineteen soil samples were obtained from natural soils from five periphery well borings. Finally, four shallow sediment samples were collected from two surface feature locations.

The ensuing discussion presents the results of each of these three solids/soils subgroups in turn. A summary of collective statistics in materials at 1-foot, 3-feet, 5-feet, and greater than 5-feet are provided in Tables 4.4-1 through 4.4-4, respectively. Sample locations are presented in Figure 4.2-5.

Considering the large volume of liquid and solid wastes disposed, few BNA compounds were detected in the refuse and soils and none were found consistently. In the landfill materials, the most commonly detected class of compounds, the phthalate esters, were found to be present in varying concentrations and depths at each boring location. Phthalates were identified above quantitation limits in 6 of 20 samples. The most frequently detected phthalate, bis(2-ethylhexyl)phthalate, was detected in each of these samples with five detections above quantitation limits. The concentrations ranged from below quantitation limits to 2,700 $\mu\text{g/kg}$. The highest concentration was detected at W01-11(F) in the sampling interval of 1 to 2.5 feet. Each of the

other detected phthalates were also found at this location and depth, though only di-n-octylphthalate was found above quantitation limits of 9,700 µg/kg. Butyl benzyl phthalate was found in one sample above quantitation limits at a concentration of 760 µg/kg. Phthalates are common plasticizing agents and their presence at these levels may be attributed to incorporation of landfill debris during sampling.

4-Methylphenol (p-cresol) was detected in two samples from W01-09(F) and W01-11(F) at 890 µg/kg and 4,300 µg/kg, respectively. Three other samples had concentrations estimated below sample quantitation limits ranging from 61 to 14,000 µg/kg. 4-Methylphenol is a common constituent of plastics, petroleum distillates, fuels, and wood.

Phenol was detected in only one sample, the one-foot sample from well boring W01-11(F), at a concentration of 2,500 µg/kg.

A total of eight VOCs were detected in the soil and sediment samples above quantitation limits and not associated with laboratory method blank contamination. Some samples containing toluene and 2-butanone (MEK) were also affected by method blank contamination; however, documentation is available indicating that each of these solvents was disposed of within the landfill.

Acetone was detected in two sediment samples (EMB-1 and EMB-4) without associated method blank contamination at concentrations of 3200 µg/kg and 2200 µg/kg, respectively.

2-Butanone was detected above quantitation limits in three samples from leachate well borings W01-09(F) and W01-10(F) at concentrations ranging from 3 to 87 µg/l. It was also reported in four other samples at estimated concentrations (below sample quantitation limits) and/or in association with method blank contamination.

Toluene was detected above quantitation limits in three well boring samples. These detections were from the deepest sample from well boring W01-09(F), and the one- and seven-foot samples from W01-10(F). The concentrations ranged from 8 to 89 µg/l in these samples. Toluene was also detected in EMB-1 at 19

µg/kg and was estimated below quantitation limits of 5 µg/kg in the three other EMB samples. Other detections were below quantitation limits or associated with method blank contamination.

Total xylenes were detected in above quantitation limits in six samples at concentrations ranging from 15 to 220 µg/kg. Xylenes are common constituents of aviation fuels, paints, and lacquers, each of which may have been placed within the landfill during its operation. It has been detected in all of the leachate wells, but not in any of the perimeter wells.

Tetrachloroethene (PCE) was detected above the quantitation limit in only the one-foot sample of boring W01-10(F). The concentration of PCE found, 7 µg/kg, is only slightly above the 5 µg/kg quantitation limit. Although the compound is a common constituent of degreasing solvents, its sparse presence suggests that the compound may not have been used extensively at the site during the lifetime of the landfill.

Carbon disulfide was detected at low levels (2 to 10 µg/kg) in three borings. Only two samples were above quantitation limits; however, these were in samples from the native soil below the landfill. While it was commonly used in electronic vacuum tubes, carbon disulfide is also emitted naturally from soils, particularly in marsh environments. Its presence in the native soils in higher concentrations than the fill material, but still at low levels, suggests it is a product of degradation of natural materials.

Ethyl benzene was detected in four samples above quantitation limits from three borings at concentrations ranging from 10 to 68 µg/kg. This compound is a common constituent of solvents and a major constituent of gasoline. It is present in all of the leachate wells but not in the perimeter wells.

Chlorobenzene was detected in the 13-foot sample from boring W01-09(F). The concentration detected is 18 µg/kg, a low level.

The minor occurrence of petroleum and solvent-related hydrocarbons in soils suggests an active biodegradation environment is present within the

landfill. Both classes of compounds may be fully or partially degraded under anaerobic and aerobic conditions.

The final class of organic compounds with multiple detections are PCBs. It has been documented that the landfill received waste transformer oils and sawdust to absorb transformer oils. PCBs were detected in six samples from three borings [W01-13(F) excluded] at concentrations ranging from an estimated 150 to 18,000 µg/kg. In each case, contamination was restricted to the landfill material and was not detected in the native material beneath the landfill.

Concentrations of metals and nonmetals in landfill soils were compared to background levels for the study area. Background soil samples were not specifically collected for this study. A discussion of the methodology and logic used for determining background concentrations are presented in Section 3.2. Baseline values are presented in Table 3.2-1.

The following elements were not detected above the baseline concentrations in any of the leachate well boring samples:

- Antimony
- Arsenic
- Cadmium
- Selenium
- Sodium.

These and other elements that were detected above one or more baseline levels are shown in Table 4.4-1. The elements that were found above baseline levels and their distribution are discussed below.

Several metals in the analytical program are elements of common rock forming minerals. For these analytes, only NAS and USGS baseline data are available because they are expected to occur in most soils. These include:

- Aluminum
- Barium
- Calcium
- Iron
- Magnesium
- Manganese

- Potassium
- Sodium.

All of these elements except sodium occurred in up to four soil and three embankment samples above the NAS baseline ranges (Table 3.5-1); however, the concentrations were only slightly above to less than twice the NAS range. These minor deviations from an averaged baseline are considered a natural variation in soils.

Beryllium was detected in seven samples above the Hetch-Hetchy baseline of 0.8 mg/kg. Of these, four samples exceeded the USGS level of 1 mg/kg and all were obtained from W01-13(F). The range of concentrations detected in the landfill samples is 0.66 to 3.3 mg/kg. None of the concentrations detected exceed the NAS background level of 3.7 mg/kg.

Chromium was detected at levels above the Hetch-Hetchy baseline of 60 mg/kg in 11 samples from various depths in all borings. Three embankment samples and two boring samples slightly exceeded the NAS baseline of 76.5 mg/kg at concentrations ranging from 76.9 to 99.2 mg/kg. Neither of the boring samples were from native soil. None of the sample concentrations exceeded the USGS baseline levels.

Copper was detected at concentrations exceeding the MV18 background of 44 mg/kg in 11 samples. In most cases the elevated concentrations were confined to the landfill material which contains metallic debris. However the sample from the native soils beneath the landfill in boring W01-09(F) contained 52.7 mg/kg, a level slightly above the MV18 baseline but below the NAS baseline. The bottom sample from boring W01-13(F) was only slightly above the MV18 baseline, but not above the Hetch-Hetchy baseline of 47 mg/kg. None of the levels detected were above the USGS background.

Lead was detected above the station baseline of 28.3 mg/kg in 8 of the 14 soil/fill samples collected from leachate wells. The samples were from various depths in all borings, and only from fill material. None of the sample concentrations exceeded the USGS baseline.

Mercury was above the Hetch-Hetchy baseline of 0.1 mg/kg in 15 samples; however, only three samples were above the NAS baseline of 0.5 mg/kg. The 13-foot sample from W01-09(F) had a mercury concentration of 6.0 mg/kg. The bottom sample in this boring had a concentration of 0.4 mg/kg. The bottom sample from W01-11(F) had a concentration of 0.9 mg/kg, but was not above the local MV18 baseline of 1.3 mg/kg. One embankment sample also exceeded the NAS baseline with a concentration of 4.6 mg/kg. These data indicate isolated area of landfill material contain elevated levels of mercury.

Nickel was above the Hetch-Hetchy baseline of 47 mg/kg in 13 samples. These samples were from various depths in all borings. Only one embankment sample and one boring sample slightly exceeds NAS baseline of 88.5 mg/kg with concentrations of 90.1 and 95.8 mg/kg. None exceeded the USGS baseline.

Silver was above the MV18 baseline of 0.4 mg/kg in six samples and three embankment samples. Three of these samples had estimated concentrations below the NAS Moffett Field project quantitation limits, and only one sample exceeded the NAS baseline. This sample exceeded all baselines with a concentration of 11.8 mg/kg. The sample was from the 13-foot depth of boring W01-09(F). The bottom sample from this boring did not contain detectable quantities of silver.

Thallium was present in estimated concentrations in one embankment and 12 boring samples above the Hetch-Hetchy baseline of 0.2 mg/kg. However, concentrations are only estimated as all were below the project quantitation limits for thallium of 2 mg/kg.

Zinc was found above the MV18 and Hetch-Hetchy baseline of 110 mg/kg in eight samples. The range of concentration of zinc in the leachate boring samples was 52 to 553 mg/kg. The samples exceeding the baselines were from various depths of all borings; however, none were from the native soil beneath the landfill. No samples exceeded the USGS baseline concentration.

A few elements were detected above the conservative baseline value but were within either the range established by the USGS or that established for the

NAS with two exceptions: silver and mercury were detected above the USGS high baselines of 5 mg/kg for silver and 5.1 mg/kg for mercury. Both metal concentrations occurred in only one sample, the 13-foot sample from well boring W01-09(F). As discussed above, the bottom samples from this boring did not contain levels of these metals above NAS baselines. Copper, chromium, lead, nickel, and zinc were found at levels above NAS baselines in fewer than 8 samples; however, none were from the native material beneath the landfill. Four other metals were found in samples from the native soil beneath the landfill at concentrations above the NAS baseline. Cobalt and vanadium were only slightly above baselines in one sample each, and thallium was above its baseline in one sample, but the concentrations are estimated below quantitation limits. Mercury was found above the NAS baseline in one bottom sample, but was still below other local baselines. These data indicate that there are elevated concentrations of metals in localized areas of the landfill only and none have migrated in significant quantities to the native soils beneath the fill. However, one embankment sample showed mercury at a relatively high concentration.

Perimeter Soils and Sediments

Chemical analyses were conducted on a total of 19 soil samples collected from five perimeter monitoring well borings and from four sediment samples collected in the wet and dry season from Jagel Slough and from the former evaporation pond north of the landfill. The sediment samples collected in Jagel Slough were accompanied by surface water samples collected at the same location. Results of soil samples from the landfill leachate borings and the landfill embankment were discussed earlier in the text. A statistical summary of detected compounds from monitoring well borings and sediment samples are presented in Table 4.4-1 through 4.4-4, and their distribution is shown on Plates E-1 and E-2 contained in Appendix E of this report.

Four VOCs were detected above quantitation limits in the 23 perimeter samples from Site 1. These include three common laboratory contaminants acetone, methylene chloride and 2-butanone, and carbon disulfide. Acetone and methylene chloride were detected in all samples at concentrations ranging from 3 to 930 µg/kg of acetone and from 12 to 93 µg/kg of methylene chloride. All of these detections were associated with method blank contamination with two

exceptions. The two exceptions were the dry season sediment sample from the Salt Flat area (SED-01, 290 µg/kg), and the dry season sediment sample from Jagel Slough (SED-02, 120 µg/kg). The highest concentration of acetone occurred in the 5-foot sample from well boring W01-07(A2) (930 µg/kg), which had associated blank contamination, and the Salt Flat sediment sample (SED-01). All other concentrations of acetone were below 200 µg/kg.

Carbon disulfide was detected in nine samples above quantitation limits (5 µg/kg). Concentrations ranged from 5 to 36 µg/kg and occurred in samples from all locations except W01-12(A1), and the Salt Flat. The occurrences were all in samples from deeper than 1 foot [sample data only from the 0.5-foot interval of W01-12(A1) are available]. As discussed previously, carbon disulfide is naturally occurring in soils as a degradation product of organic material common to estuarine environments.

One BNA compound, 4-methylphenol, was found in the wet season sample from Jagel Slough at 1,200 µg/kg.

Perimeter soil samples were compared to baseline concentrations presented in Table 3.5-1. The following metals were not detected above baselines in any soil or sediment samples:

Antimony
Cadmium
Calcium.

The concentrations of elements detected above baseline and their distribution are shown on Plate E-2.

As discussed earlier, several metals in the analytical program are naturally occurring in soils at variable levels. This is a result of variation in elemental content of rock forming minerals and their eventual uneven distribution in sediments. These include:

- Aluminum
- Barium
- Calcium
- Iron

- Magnesium
- Manganese
- Potassium
- Sodium.

All of these elements except for calcium occurred in soil samples above the NAS baselines (Table 3.5-1). Concentrations of these elements were only slightly above to less than two times the NAS range and, as previously discussed, are considered a natural variation in soil chemistry. The exception was a sediment sample from the Salt Flat which had a significantly greater concentration of sodium than the station average. However, as sodium is a major component of salt water, this is not unexpected.

Arsenic was detected above the Hetch-Hetchy baseline of 6.3 mg/kg in seven soil samples and two sediment samples. Five of these samples were slightly above the NAS baseline of 8.8 mg/kg with a high concentration of 11.1 mg/kg. These occurrences were from four of the borings at variable depths above 10 feet. Their slightly elevated levels and sporadic distribution are not indicative of soil contamination due to migration of leachate from the landfill.

Beryllium was detected above the Hetch-Hetchy and USGS baselines of 0.8 and 1 mg/kg in nine soil samples. Two sediment samples were above the Hetch-Hetchy baseline. The concentration range is from 0.93 to 5 mg/kg. Samples exceeding Hetch-Hetchy and USGS baselines were from all well and sediment locations except W01-08(A1). The sample from well W01-12(A1) at 0.5 feet contained beryllium at 5 mg/kg, which is slightly above the NAS baseline of 3.7 mg/kg.

Chromium was detected above the Hetch-Hetchy baseline of 60 mg/kg in 13 soil and 2 sediment samples. Concentrations ranged from 23.7 to 118 mg/kg and were found above baseline at various depths at all locations. These concentrations are not significantly greater than the NAS baseline of 76.5 mg/kg. None were greater than the USGS baseline value of 2,000 mg/kg.

Cobalt was found above the NAS baseline of 18.6 mg/kg in four soil and one sediment samples. These samples were from most borings at various depths and had a high concentration of 24.1 mg/kg, only slightly above the station base-

line. None of these samples had concentrations above the USGS baseline of 70 mg/kg.

Copper was found above the MV18 baseline of 44 mg/kg in four soil samples. Only the 1-foot sample from W01-05(A1) (121 mg/kg) and the 0.5-foot sample from W01-12(A1) (137 mg/kg) were also above the station baseline of 56.7 mg/kg. The concentration range of all soil and sediment samples is 9.5 to 137 mg/kg, below the USGS baseline of 700 mg/kg.

Lead was detected above the station baseline of 28.3 mg/kg in three soil and two sediment samples. The soil samples were from the 1-foot depth of W01-05(A1) at 41.5 mg/kg and from the 5- and 10-foot depths of W01-07(A2) at 34.0 and 49.5 mg/kg, respectively. None of those measurements exceeded the MV18 or USGS baselines. Sediment samples with concentrations above baseline at 78.2 and 48 mg/kg were from the Salt Flat area. Only the dry season sample was notably above baseline, and no samples were greater than the USGS baseline of 700 mg/kg.

Mercury was detected above baseline of 0.1 mg/kg (Hetch-Hetchy) in 16 soil and 4 sediment samples. Only four soil and two sediment samples exceeded the NAS baseline of 0.5 mg/kg with a high of 1.2 mg/kg in the 3-foot sample from W01-05(A). Other samples from this boring had concentrations of 0.7 and 0.9 mg/kg, which represent the other highest exceeding values. These concentrations are not greater than the MV18 baseline of 1.3 mg/kg, and are probably representative of natural variation in the soils.

Nickel was above the Hetch-Hetchy baseline of 47 mg/kg in 15 soil samples and three sediment samples. The concentration range is 32.9 to 118 mg/kg. These concentrations do not exceed the USGS baseline and are only slightly above the NAS baseline (88.5 mg/kg).

Selenium was estimated to be above baseline values of less than 0.3 mg/kg (Hetch-Hetchy and MV18) and 0.5 mg/kg (USGS) in three samples. However, the concentrations were all below sample quantitation limits and were estimated at 0.98 to 1.2 mg/kg.

Silver was detected above the MV18 and Hetch-Hetchy baselines of 0.4 and 0.8 mg/kg in two soil samples. The 1-foot sample from W01-06(A1) had a concentration of 2.4 mg/kg and the 10-foot sample had value estimated below quantitation limits of 1.26 mg/kg. Both of these values are within the NAS and USGS baselines of 5 mg/kg.

Thallium was estimated to be above the Hetch-Hetchy baseline of less than 0.2 mg/kg in one sediment and 13 soil samples and above the NAS baseline in all but one of those samples. However, all concentrations were estimated below the quantitation limits of 2 mg/kg for the NAS Moffett Field project.

Vanadium was above the NAS baseline of 78.2 mg/kg in one sediment and ten soil samples. The concentration range was from 37.5 to 102 mg/kg, with the high value not significantly greater than the baseline. These samples were from various depths in all borings except W01-12(A1), and appear to represent natural variation of element concentration.

Zinc was found above the NAS baseline of 104.1 mg/kg in seven soil and one sediment samples. Concentrations in the wet season Salt Flat sample (113 mg/kg), and from six well boring samples (108 mg/kg to 134 mg/kg) were only slightly above the baseline. The 1-foot sample from W01-05(A1) had a concentration of 202 mg/kg which is well below the USGS baseline of 3,500 mg/kg.

Leachate

Four shallow monitoring wells screened in fill material were sampled quarterly over a one-year period. Leachate samples from Site 1 were analyzed for VOCs, BNAs, PCBs, metals, and ions. Volatile and BNA compounds detected in the leachate from these wells are presented in Table 4.4-6 and their distribution is shown in Plate E-11 (Appendix E of this report). The inorganic distribution is presented in Plate E-12.

A total of nine VOCs were detected above quantitation limits consistently (in 50 percent or more of the sample rounds) in one or more leachate wells at Site 1. The most frequently detected volatile compounds were the common laboratory contaminants acetone and methylene chloride. In more than 50 percent of the cases, each detection of acetone was associated with method blank contamina-

tion, and all methylene chloride detections had associated blank contamination. The actual presence of these two compounds in the leachate is suspect.

Ethyl benzene and xylenes were detected consistently in one and three leachate wells, respectively. Ethyl benzene concentrations ranged from 5 to 150 $\mu\text{g/l}$. Concentrations of xylenes ranged from 6 $\mu\text{g/l}$ to 350 $\mu\text{g/l}$. Toluene was found in two wells consistently with concentrations ranging from 7 $\mu\text{g/l}$ to 440 $\mu\text{g/l}$. In addition to their use in solvents and paints, these compounds are also components of gasoline and other low boiling point fuels. Records indicate that solvents, paints, and fuel filters were disposed of within the landfill and are therefore considered the most likely source of the compounds in the leachate.

Chlorinated hydrocarbons were not detected in any of the samples except for trace amounts of 1,4 dichlorobenzene which was found consistently in one well [W01-10(F)] at concentrations ranging from 14 to 33 $\mu\text{g/l}$. The lack of these chemicals in fill wastes is consistent with their absence noticed in fill soil samples.

4-methyl-2-pentanone was detected consistently in two leachate wells. Concentrations ranged from 16 $\mu\text{g/l}$ to 8,300 $\mu\text{g/l}$ with the high concentration in well W01-11(F). 2-butanone was detected consistently in W01-09(F) only, at a concentration range of 110 $\mu\text{g/l}$ to 1,000 $\mu\text{g/l}$. Two other occurrences in well W01-10(F) were 290 $\mu\text{g/l}$ and 49,000 $\mu\text{g/l}$. Records indicate that each of these solvents were disposed of within the landfill. 2-Butanone is also used as a standard cleaner for sampling equipment.

Two BNA compounds were consistently detected above quantitation limits in two of the leachate wells. 4-methylphenol was detected consistently in two wells at a concentration ranging from 23 to 7,900 $\mu\text{g/l}$. The higher concentrations were found in well W01-09(F). Benzoic acid was detected consistently in monitoring well W01-09(F) (1,600 $\mu\text{g/l}$ to 11,000 $\mu\text{g/l}$). Benzoic acid is a typical organic byproduct and is naturally occurring in vegetation. It is also used as a corrosion inhibitor in coolants, machine oils, greases, and lubricants. Several other BNAs were found in leachate well samples (see Table 4.4.6), but the occurrences were not consistent.

A comparison of organic compounds detected in both leachate and landfill soils indicates that the majority of compounds were detected in both matrices, with some exceptions. 1,4-dichlorobenzene and benzoic acid were not detected in the landfill material, and 4-methyl-2-pentanone was detected in only trace amounts. Samples from the leachate wells contained these compounds. PCBs were found in three landfill soil samples at shallow depths at concentrations up to 18 mg/kg. Only one leachate sample from W01-10(F) contained detectable levels of these compounds.

Metals which are naturally occurring constituents of seawater were found in high concentrations in leachate monitoring well samples. Additionally, several elements which occur naturally in high concentrations in soils are also high in leachate. Elements in these categories and their concentration ranges are:

<u>Elements</u>	<u>Range (µg/l)</u>
Calcium	11,600 to 570,000
Iron	411 to 108,000
Magnesium	27,800 to 1,790,000
Manganese	1 to 3,600
Potassium	14,400 to 812,000
Sodium	153,000 to 23,600,000

Two other metals were reported consistently above quantitation limits in leachate wells. Arsenic levels ranged from 11.0 to 34.1 µg/l with consistent detections in Well W01-10(F) and barium ranged from 315 to 6,580 µg/l with consistent detections in W01-09(F) and W01-11(F). Other metals were detected but not consistently. The number of detections above sample quantitation limits and the concentration ranges of these elements are shown in Table 4.4-6, and their distribution is shown Plate E-12.

Ground Water

Ground water samples were collected from four A1- and one A2-aquifer monitoring wells at Site 1. Samples were analyzed for VOCs, BNAs, PCBs, metals, and ions. Chlorinated volatile organic compounds were not detected in any sample except for the laboratory contaminant methylene chloride. Methylene chloride

was detected in nearly all samples, but always in association with method blank contamination. The range of concentration for methylene chloride was from 5 µg/l to 21 µg/l . Another laboratory contaminant, acetone, was also detected in almost all samples and almost all detections were associated with blank contamination. The concentration range for acetone was 10 µg/l to 31 µg/l and only two samples had concentrations above quantitation limits that did not have associated blank contamination [W01-08(A1) at 10 µg/l and W01-12(A1) at 11 µg/l].

No other organic compounds were detected consistently in any A-aquifer wells. One VOC, carbon disulfide, was detected in two samples, W01-06(A1) at 42 µg/l and W01-08(A1) at 6 µg/l. Four BNA compounds were detected one time at concentrations of less than 40 µg/l. 2-Chlorophenol, 4-chloro-3-methylphenol, and phenol were detected in W01-05(A1), and di-n-octyl phthalate was detected in W01-12(A1).

Saltwater intrusion in the Site 1 area has resulted in very high dissolved solids concentrations, particularly of common seawater ions. These high concentrations have generally required high dilution factors for inorganic chemical analysis. As a result, many of the reported values for metals concentrations are suspect due to potential interferences from the high TDS. Ranges of the reported values are quite variable due to the elevated quantitation limits. Table 4.4-5 shows the ranges of concentrations for inorganic analytes in ground water samples from the A aquifer. Distribution are portrayed in Plate E-12.

Common seawater ions were detected consistently in all of the Site 1 wells. These include calcium, magnesium, potassium, and sodium. The concentrations of these ions are slightly higher than those of typical seawater shown in Table 3.5-2.

Two metals were detected consistently in ground water monitoring wells. Iron was detected at concentrations ranging from 181 µg/l to 340,000 µg/l. The highest concentration (340,000 µg/l) was found in one sample from W01-08(A1); however, five other samples from this well ranged from 1,810 µg/l to 3,140 µg/l, making a single occurrence at 340,000 µg/l suspect. Iron was also found

in notably higher concentrations in well W01-12(A1). Iron levels in this well ranged from 5,480 to 10,300 $\mu\text{g/l}$. Other values of iron at Site 1 were below 4,800 $\mu\text{g/l}$. This level is not substantially higher than the regional levels of <10 $\mu\text{g/l}$ to 2,700 $\mu\text{g/l}$ reported by the DWR (Table 3.5-1).

Manganese was detected consistently in the A-aquifer wells at a concentration range of 169 $\mu\text{g/l}$ to 8,260 $\mu\text{g/l}$, and a mean value of 3,813 $\mu\text{g/l}$. These values are notably higher than the regional levels of <10 $\mu\text{g/l}$ to 410 $\mu\text{g/l}$ reported by the DWR (Table 3.5-1). However, the values are also higher than those found in leachate wells (Table 4.4-6). This suggests that the manganese content is naturally occurring rather than a result of landfill leachate migration to the A aquifer.

All metals and nonmetals included in the analytical program were detected above sample quantitation limits at least one time in the 33 ground water samples. Other than those discussed above however, none were detected above sample quantitation limits consistently in the A-aquifer wells.

In summary, A-aquifer monitoring wells do not show degradation of ground water quality by organic compounds. As can be noted from the soils and leachate data a local source for organic solutes is not evident. Further, the minor amounts of soluble organics which may be present in the landfill leachate have not migrated to underlying ground water. Interpretations of ground water level monitoring (Appendix B), aerial photographs, and geophysical surveys (Section 4.3) indicate a trench existed in the landfill area during its operation which may provide a pathway for migration of leachate outside the landfill aquifer. The importance of this feature is at this time still unknown.

Results of inorganic analyses of A-aquifer samples are suspect due to the high salinity of the water. However, the lack of consistent detections of most metals and the variability in concentrations from sample to sample in each well are not indicative of contamination.

5.0 GOLF COURSE LANDFILL - SITE 2

5.1 DESCRIPTION AND HISTORY

The Golf Course Landfill is located just west of the golf course at the intersection of Patrol Road and Zook Road and adjacent to a salt evaporation pond (Figure 5.1-1). This landfill was in operation from the 1940s to the early 1960s. Little information is available on the types or the quantities of waste disposed. It covers an area of approximately seven acres and is bordered by Zook Road on the west, Macon Road on the south, Patrol Road on the north, and Building 561 and its enclosure on the east. The site is basically flat and open except for some mounded areas where debris is visible at the surface. The site is enclosed by a chain link fence on the north and west and portions of the south and east. Ground cover throughout the site is predominately low grass and brush.

Reportedly, this site was used in a similar manner as the more recently operated Runway Landfill and may have received some of the same types of hazardous waste. A burn pit in the present golf course area was used for disposal of outdated flares and cartridge-activated devices until 1971.

Records of disposal at the Site 2 landfill are not available. Station reports indicate this site was used by the same shops and to the same degree as the more recent Site 1 landfill. Site 2 was operated to accept refuse, debris, and scrap equipment; however, various shops at NAS Moffett Field used the landfill to dispose of hazardous waste. Disposed hazardous wastes, from the variety of shops, including the aircraft squadrons, are presumed to be:

- Trichloroethene (TCE), toluene, methyl ethyl ketone (MEK), solvents, including Stoddard Solvent (75,000-150,000 gallons)
- Ash (69,000 pounds)
- Asbestos (16,000 pounds)
- Paints, lacquer, and thinners (43,500 gallons)
- JP fuels (unknown amounts)
- Waste oil (unknown amounts, buried 55-gallon drums)

- Used lube oil (unknown amounts)
- 1,440 fuel filters with fuel sludge, lead compounds, and rust
- Transformer oil (870 gallons),
- Transformer oil filters
- Sawdust contaminated with transformer oils possibly contaminated with PCBs.

Assuming the squadrons disposed of 5 to 10 percent of their liquid waste at Site 2, the total volume of hazardous waste disposed here may range from 75,000 to 150,000 gallons.

A previous study to define the landfill boundaries (ESA, 1986a) appears to have incorrectly identified the location of the landfill. The landfill apparently is located farther to the northwest than shown in the ESA report. The potential landfill boundaries, indicated in Figure 5.1-1, are based on a review and analysis of several aerial photographs and a geophysical survey performed in 1988 during this study and described in subsection 5.3.2.

5.2 FIELD INVESTIGATION

The investigation at Site 2 included the following activities:

- Surface geophysical surveys.
- Continuous soil coring from borings around the periphery of the landfill.
- Geophysically logging deep borings.
- Installation of monitoring wells within and around the landfill.
- Laboratory (permeability) testing in natural soils from beneath the landfill.
- Surface water and sediment sampling in and around the landfill.
- Analyzing water, soil, sediment, and leachate samples for organic and inorganic chemicals.

5.2.1 Geophysical Survey

Electromagnetic induction methods of conductivity measurements were used to measure terrain conductivities along 11 traverse lines which ranged in length

from 180 feet to 670 feet. The total lineal coverage was 5,160 feet. In addition, five vertical electric soundings were performed. The locations of the terrain conductivity profiles and vertical electric soundings are shown on Figure 5.2-1. Figure 5.2-2 is a contour map showing the distribution of terrain conductivity across the site. Areas of low conductivity [<200 milli-siemens per meter (mS/m)] indicate the areas of possible fill material and areas of high conductivity (>325 mS/m) represent native soils such as clay and silt. An orthogonal projection of results is given on Figure 5.2-3. A geoelectric cross section, Figure 5.2-4, depicts the variation of electrical resistivity with depth, suggesting a maximum depth of fill of approximately 8 feet. Together these diagrammatic sketches illustrate the boundary between landfill material and native soil.

Well defined gradient changes are not evident in the terrain conductivity to indicate a sharp contrast or boundary between fill and native material. Mounded areas, surface debris, and excavations roughly correlate with the low terrain conductivities, indicating the fill area. Two elliptical zones, labeled A and B on Figure 5.2-2, of anomalously high conductivity protrude into the low conductivity area. These features may represent portions of the landfill containing metallic debris. The survey of the area extends 300 feet south of the landfill boundary and indicates a broad area of low conductivity. This low conductivity is probably due to a large abandoned asphalt parking area and not an extension of the landfill itself. Generally the vertical extent of the fill material ranges from a base at about -1.6 feet msl and a top of 8.0 feet msl. Thickness of the fill is highly variable due to the mounding which was present at well locations throughout the landfill and the broad transition on the conductivities from fill to native material. The results of surface geophysical studies deviate from observations made from shallow monitor well borings. Well borings suggest the refuse may extend as much as 21 feet below local grade.

A previous surface geophysical study was conducted at the landfill (ESA, 1986b) using a magnetometer. The study revealed two areas at the southern portion of the landfill which could contain buried metallic objects. These areas may correspond to the elliptical anomalies detected by this study's geophysical study. The ESA study seems to have incorrectly identified the

location of the landfill. The landfill is actually located further to the northwest than indicated by the ESA report. The estimated limits of the landfill as investigated by ESA, as described in the 1988 RI/FS SAP (IT, 1988b), and after performing the RI geophysical study is shown on Figure 5.2-5.

5.2.2 Geophysical Borings

Three geophysical borings, GB-1, GB-2, and GB-3, were drilled around the periphery of the landfill. The borings were continuously cored and geophysically logged. Locations of these borings are shown in Figure 5.1-1, and boring and geophysical logs are presented in Appendices I and J, respectively, of the December 1988 Quarterly Report (IT, 1988e). Geophysical Boring-1 is 157 feet deep, GB-2 is 157 feet deep, and GB-3 is 243 feet deep. All borings were completed in unconsolidated materials. Downhole geophysical electric logs included point resistivity, spontaneous potential, and natural gamma. Caliper logging of the borings was also conducted.

5.2.3 Soil Borings

Twelve borings were drilled at Site 2 for geophysical information, physical soil properties, waste characterization, and chemical composition. Depths varied from 10 to 25 feet.

5.2.4 Ground Water Monitoring Wells

A total of seven wells were installed during this phase of the study. Three were screened in shallow saturated lenses within the fill (denoted here as leachate wells) and four wells were completed in the A aquifer. The leachate monitoring wells are W02-08(F), W02-10(F), and W02-11(F). The leachate well boreholes were extended through waste materials into native soil for collection of soil samples beneath the fill material and conductance of slug tests. The boreholes were then filled with bentonite up to the bottom of the fill material and the well was constructed in the fill material. Leachate wells vary in depth from 15 to 24 feet and are designed to monitor soil moisture as it moves through fill material. Leachate well construction information is included in Appendix I, of the December 1988 Quarterly Report (IT, 1988e). Locations of the wells are shown on Figure 5.1-1.

Monitoring wells W02-05(A1), W02-06(A1), W02-07(A2), and W02-09(A1) were installed at Site 2 to monitor ground water quality in the A aquifer. Wells W02-09(A1) and W02-06(A1) were installed in the presumed upgradient and downgradient locations for the landfill, respectively. Wells W02-05(A1) and W02-07(A2) were installed around the perimeter of the landfill. Monitoring wells vary in depth from 21.5 to 40 feet and are used to monitor ground water as it moves through natural material. Well locations are shown on Figure 5.1-1, and boring logs are presented in Appendix I of the December 1988 Quarterly Report (IT, 1988e). Monitoring well construction information is included in the log of each well and is summarized in Table 2.3-2. One boring, SB02-01 shown on Figure 5.1-1, was drilled for the purpose of determining the depth of the landfill. This borehole was for physical characterization of materials only, and no samples were collected for chemical analysis.

5.2.5 Permeability Tests

Seven laboratory permeability and effective porosity tests were conducted on drive samples from the bottom of each new monitoring well boring. Sampling depths ranged from 14 to 23 feet bls. All samples except for W02-05(A1)MD5 were clay soils. Sample W02-05(A1)MD5 was classified as a clayey sand. Effective (drainable) porosities determined to be from 36 to 44 percent were consistent with typical clays. The clayey sand exhibited a porosity of 27.4 percent. Permeabilities for clay samples ranged from 2.1×10^{-8} to 5.9×10^{-8} cm/sec and the clayey sand sample was 3.6×10^{-4} cm/s. Table 5.2-1 presents a summary of results.

In situ rising head slug tests were also attempted in each of the site fill wells. Operational problems were encountered during the conduct of these tests and as a result, values obtained were not considered to be representative of native materials.

5.2.6 Soil Samples

Soil samples for chemical analyses were collected from all leachate and ground water monitoring wells. Samples were collected from 1-, 3-, and 5-foot depths, and from a 10-foot depth or immediately above the water table. Also, one soil sample was collected from the native soil at the bottom of each leachate well

boring to assess vertical migration of contaminants beneath the landfill. A total of 28 soil samples were collected.

Soil and sediment samples were analyzed for VOCs, metals, pH, PCBs, and BNAs. The analytical results of all soil and sediment samples were presented in the December 1988 Quarterly Report (IT, 1988e). A summary compilation of analytical data is given in Appendix C of this report.

5.2.7 Ground Water Samples

Ground water and leachate samples were analyzed for VOCs, BNAs, PCBs, metals, TDS, pH, specific conductance, and major anions. Ground water sampling was completed by August 1989. Analytical results were presented in the December 1988 Quarterly Report (IT, 1988) and the August 1989 Quarterly Report (IT, 1989c). A summary compilation of ground water data is given in Appendix D.

5.2.8 Surface Water and Sediment Samples

Surface water and sediment sampling was conducted at one point in the salt water evaporation pond. The location of the sampling point is shown on Figure 5.1-1. Surface water and sediment sampling was conducted in wet and dry seasons. Dry season sampling was completed by December 1988. Surface water and sediment samples were analyzed for VOCs, BNAs, PCBs, metals, TDS, pH, specific conductance, and major anions. The analytical results were included in the December 1988 Quarterly Report (IT, 1988). Wet season analytical results were reported in the August 1989 Quarterly Report (IT, 1989c). Summary analytical results are presented in Appendix C for soil samples and Appendix D for water samples.

5.2.9 Water Level Measurements

Monthly water level measurements were made at each well for a period of one year. Summary hydrographs for individual wells are provided in Appendix A and potentiometric maps are presented in Appendix B of this report.

5.2.10 Aerial Photography Study

The earliest available aerial photograph was taken in 1947, and it shows the Site 2 landfill in operation at that time. The landfill appears as a shallow

excavation. Little change appeared in the Site 2 landfill from that time until 1963 when it was totally filled and abandoned.

5.3 HYDROGEOLOGY

5.3.1 Site Geology

The stratigraphic units penetrated by borings at Site 2 range in age from Pleistocene to Holocene and represent estuarine environments and fluctuations of an estuarine/alluvial boundary due to sea level changes. Saturated zones of silty sand and sandy clay below the uppermost clay layers make up the upper A aquifer. An isometric depiction (fence diagram) of the subsurface stratigraphy beneath Site 2 is shown in Figure 4.2-6.

Logs of geophysical borings into the lower alluvial materials show that silty clay is interfingered with sandy clayey gravel and sand lenses. The data also indicate variable thicknesses and limited areal extent of these lenses. Geophysical Boring GB-01 shows an extensive sandy clay from land surface to about 22 feet. There is a 6-foot thick silty clay to 28 feet and then a continuous sandy clay to clayey sand to about 105 feet.

Logs of geophysical borings in the upper alluvial materials reveal silty clay which is mostly brown with some gray in places and is plastic in nature. An intermediate zone exists, consisting of interfingered sand and silty sand which varies in color from tan to brown and is non-plastic. The sand and silty sand seems to be consistent areally at the site; however, the thickness varies from location to location. At boring W02-05(A1) the silty sand of the A1 subaquifer is about 7 feet thick. At boring W02-06(A1) the silty sand of the A1 subaquifer is about 2 feet thick. Boring W02-07(A2) has a silty sand grading into a clean sand that is about 4 feet thick in the A1 zone and boring W02-09(A1) has a sandy clay which is about 3 feet thick in the uppermost conductive layer (A1).

5.3.2 Hydrology

Surface Water

There is minimal topographic relief at Site 2 and the area is graded to drain surface water flow into local drainage ditches that convey the runoff to a canal along the northern boundary of the station. The water is then pumped from this

perimeter canal to an off-site canal that eventually discharges to Guadalupe Slough. Although the landfill is constructed above grade, the debris-littered surface aids in infiltration of runoff resulting in little or no erosion.

Vadose Zone

Because of the low topography, and subsidence caused by the pumping of ground water, water levels at Site 2 are below sea level. The water levels in wells at the site range from 9 to 15 feet bls with the material between the saturated zone and the land surface consisting primarily of fill. The water table in the fill is variable and represents a perched condition with downward migration of moisture into the A1 subaquifer.

Ground Water

Aquifers underlying the site consist of silty sand or sand and gravel deposits separated by relatively impermeable silts and clays. These sand and gravel aquifers vary in thickness and appear to be laterally discontinuous. The thickness of the water bearing units in the A aquifer vary from 2 to 7 feet thick and are from 17 to 35 bls. The A aquifer consists of silty sands, clayey sands, and gravelly sand. Numerous saturated pockets or perched layers were encountered within the fill material which may or may not be directly connected to the underlying A aquifer system. The A aquifer can be divided into two subaquifers, one at about 15 feet and the second at about 35 feet [see borings W02-05(A1) and W02-07(A2)]. Only well W02-07(A2) is screened in the lower portion of the A aquifer.

Above the A aquifer is the variably saturated fill which is not related to "natural" aquifers. Hydraulic conductivity of the material beneath Site 2 was measured using slug tests in wells. All slug tests were conducted in native material beneath the fill. However, the results of the test were evaluated and considered invalid due to leakage around the drive casing. Data obtained from other sites at NAS Moffett Field indicated hydraulic conductivities for the A aquifer in the range of 1×10^{-2} cm/sec to 1×10^{-5} cm/sec. The first value is indicative of a silty sand and the second value represents a silt. The B2 and B3 subaquifers are composed of clayey sands and clayey gravel found at depths from 45 to 110 feet, and also appear to be discontinuous. Information about the C aquifer was obtained from geophysical borings which were of sufficient depth

to reach this aquifer. At Site 2 no monitoring wells were established in the B or C aquifers.

Based on September 1988 data (Figure 5.3-1), ground water at the site moves generally north northwest. The flow is radial due to the mounding effect produced by the fill and moves toward the pump station which discharges water over the dike to prevent flooding of this low area. The slope of the gradients and the directions of ground water flow indicate that sea water could easily move into the area. Seasonal variation of the ground water is minor.

5.4 NATURE AND EXTENT OF CONTAMINATION

5.4.1 Sources

The primary source of potential contamination to the soils, surface water, and ground water at Site 2 is the landfill contents. As previously described, the landfill received various waste solvents, refuse, and scrap equipment from the 1940s to the early 1960s.

5.4.2 Review of Chemical Analysis

Soils

A total of 28 soil samples from landfill materials and perimeter well borings were sampled and analyzed (including four duplicates). Volatile organic compounds and base-neutral acid extractable compounds detected in the soil samples from 1-, 3-, 5-, and greater than 5-feet are presented in Tables 5.4-1 through 5.4-4. The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each sample was associated with method blank contamination. In the following discussion, compounds will be discussed only where they are above quantitation limits or where the compounds are not found in the associated method blank.

Generally, organic compounds were not detected at the site. At the 1-foot depth level, the only compound detected above trace levels (10 µg/kg) was total xylenes. Xylenes were found only from location W02-09(A1), which is hydraulically upgradient of the landfill. At the 3-foot depth level, no BNAs or VOCs were detected. At the 5-foot depth level, bis(2-ethylhexyl)phthalate was

detected in two samples [from W02-05(A1) and W02-06(A1)]. In both cases, duplicate samples were analyzed and the compound was only detected in one of the analyses. Benzo(b)fluoranthene was detected in one sample [from W02-11(F)]. Below the 5-foot depth, no VOCs or BNAs were detected in any of the samples, including the samples of native soil immediately below the landfill.

PCBs (Aroclors 1242 and 1254), were detected in three soil samples from fill materials. At the 3-foot depth, PCBs were detected in two samples. Aroclor 1242 and Aroclor 1254 were detected in the sample from location W02-08(F), and Aroclor-1254 was detected at location W02-10(F). At the 5-foot depth, Aroclor-1254 was also detected in one sample from W02-10(F). The concentration of Aroclor 1254 in W02-08(F) at 3 feet was 20,000 µg/kg and in W02-10(F) at 5 feet 28,000 µg/kg.

A summary of metals and inorganic compounds detected in soils from Site 2 is also presented in Tables 5.4-1 through 5.4-4. Background soil samples were not specifically collected for this study. Baseline ranges for inorganic constituents were determined as discussed in Section 3.1. The following discussion will focus on constituents detected above the baseline range.

A review of soils data suggests that most inorganics are present within typical ranges for local soils. Slightly elevated inorganics were detected almost exclusively within the 3- and 5-foot sampling depths, which are representative of refuse derived or affected materials. Inorganics exhibiting concentrations of note are arsenic, cadmium, chromium, copper, nickel, and zinc.

Arsenic was detected in 5 of the 28 soil samples analyzed. Concentrations ranged from 2.6 to 35.1 mg/kg. Arsenic concentrations found at the 1-, 5-, and greater than 5-foot levels, were all less than 5.0 mg/kg, within the baseline of 6.3 mg/kg. Elevated levels detected were limited to the 3-foot samples where concentrations ranged from 2.6 to 39.6 mg/kg in the five samples containing arsenic. Of these five samples only two exceeded the upper boundary of the NAS Moffett baseline (8.8 mg/kg). These samples were from well borings W2-6(A1) and W2-7(A2).

Cadmium was elevated in a few samples taken from refuse (3- and 5-foot) samples. It was detected in one sample below 5 feet and was within typical soils concentrations of 1.0 to 3.0 mg/kg in surface soils (USGS, 1984). Two samples from the 3-foot depth and one sample from the 5-foot depth exceeded the baseline of 3.0 mg/kg. A single detection of 218 mg/kg at the 3-foot level in W02-06(A1) was an order of magnitude above any other sample. Four samples were taken from this boring at 1-, 3-, 5-, and 10-feet. The 1-foot sample contained 1.7 mg/kg cadmium and neither the 5-foot or the 10-foot sample contained cadmium.

Chromium was detected at slightly elevated concentrations in native and fill materials. No samples tested for chromium exceed 2 times the low baseline of 60 mg/kg. Detected most often at the 3 foot level (5 times), the high concentration is 137 mg/kg which was found in a fill sample from W2-10(F). The majority of these samples lie within a natural soil range.

Similar observations can be made for copper, nickel, and zinc. Concentrations are only slightly elevated (typically less than twice background) and are subject to random distribution. A notable measurement of zinc at 43,000 mg/kg in a 3-foot sample from W02-06(A1) is two orders of magnitude greater than any other analyzed. Three other samples taken from the same well contained about 100 mg/kg. The particular high number may be a result of leaching metals from brass during the sample extraction process.

Analysis of soil samples from periphery boings showed only low level xylenes in one sample from a boring upgradient of the landfill. Other organic contaminants were below quantitation limits, associated with laboratory blank contamination, or were not confirmed by duplicate analysis.

Inorganic analysis of soil samples showed that most inorganics are present within typical ranges for local soils, or at levels only slightly elevated above baselines. However, arsenic was found at a concentration that was about four times the baseline in a soil sample from the 3-foot depth of a periphery well boring. Five inorganic constituents were found at levels significantly elevated above baselines. All of these constituents, arsenic, barium, cadmium, copper, and zinc, were found in one sample from the 3-foot depth of well boring [W2-6(A)]. The upper portion of this boring was drilled through fill. However,

because other soil samples from intervals described on logs as containing fill material did not contain similar concentrations of these metals, it would be prudent to review the analytical data reduction calculations.

Ground Water

A total of 13 ground water samples (including one duplicate) were collected and analyzed. Samples were analyzed for BNAs, VOCs, PCBs, and metals.

In general, BNAs are not present in the ground water. BNAs were not detected in wells installed in the A aquifer and only trace amounts were found in wells monitoring leachate. Naphthalene was detected in leachate wells from 12 $\mu\text{g/l}$ to 50 $\mu\text{g/l}$. Summary statistics for ground water analyses of all types is provided in Table 5.4-5 (A aquifer) and Table 5.4-6 (fill) wells. The limited PCBs detected in soil were not detected in any ground water samples.

The most frequently detected VOCs were acetone and methylene chloride. In most cases, each sample was associated with method blank contamination. As previously mentioned, acetone and methylene chloride are common laboratory contaminants. The following compounds were detected above quantitation limits (and not in associated method blanks) in wells monitoring leachate: 1,2-dichloroethene [1 sample from W02-08(F)], benzene [two samples from W02-08(F), and one sample from W02-10(F)], tetrachloroethene [one sample from W02-08(F)], [total xylenes one sample from W2-06(A1)], and vinyl chloride [one sample from W02-08(F)].

Only one monitoring well screened around the perimeter of the landfill exhibited any VOCs. One sample from W02-06(A1) contained 8 $\mu\text{g/l}$ of total xylenes. This was a single occurrence and therefore the actual presence of xylene in matrix ground water appears suspect. The data indicate that VOCs present are in trace levels and restricted to leachate. The highest concentration of any VOC was vinyl chloride at 42 $\mu\text{g/l}$ and similar to the detection of benzene the presence of vinyl chloride could not be confirmed in any of the other five sample rounds.

Two observations can be drawn from this data set. First, there appears to be no significant source of soluble organics which may cause environmental contamination. Secondly, mobile organics detected are limited to refuse moisture and have not migrated to the A1 subaquifer.

Naturally occurring inorganic constituents within the soils (aluminum, calcium, sodium, potassium, and magnesium) are also present in high quantities in the ground water. Salt water intrusion in this area has contributed greatly in natural degradation of water quality with respect to inorganic compounds. Inorganics associated with contamination conversely, are minimal. This phenomena was expected based on the general lack of anomolous quantities of inorganics within natural soils and fill materials. Similarly, inorganic parameters occurring above quantitation limits are: barium [two samples from W02-10(F)], iron [two samples from W02-10(F)], lead [one sample from W02-07(A2)], manganese (12 samples), and nickel [one sample from W02-08(F)].

Surface Water

One surface water location was sampled twice: Once to represent the wet season (sample No. MOF-462) and once to represent dry season (sample No. MOF-16). No BNAs or VOCs were detected above quantitation limits except when associated with method blank contamination. PCBs were also not detected in either of the two samples. Naturally occurring inorganic constituents within the soils (aluminum, calcium, manganese, potassium, and sodium) were found in similar concentrations as ground water. There were no anomolous detections of contamination associated inorganics such as lead, copper, zinc, nickel, and chromium. A summary of specific results for these samples is provided in Appendix D.

From the data collected to date, surface water quality degradation due to site activities is not evident.

Surface Sediments

Two surface sediment samples were collected at Site 2. The only VOC detected in the samples not also detected in the method blank was carbon disulfide which was detected in trace amounts in one of the samples (10 µg/kg). Laboratory contaminants, acetone and methylene chloride were detected in both samples. No other organic compounds were detected above quantitation limits. Locations of these samples are shown in Figure 5.1-1.

Metals concentrations similar to natural soils (1-foot and greater than 5-foot levels) at the site that were detected above baseline levels included; arsenic

(one sample above the low baseline of 6.3 mg/kg but not above the NAS baseline of 8.8 mg/kg), chromium (one sample), mercury (one sample above NAS baseline but not above the MV-18 baseline), and nickel (one sample). Concentrations of these elements were not significantly above NAS baselines.

From these data, it can be concluded that ground water quality degradation due to site activities has been minimal. In addition, samples of soils and ground water directly in source materials suggest a minor potential for contaminant contribution to the surrounding environment at this time.

6.0 MARRIAGE ROAD DITCH - SITE 3

6.1 DESCRIPTION AND HISTORY

Marriage Road Ditch runs northward along the east side of Marriage Road, carrying surface drainage from the intersection of Marriage and Macon roads to a perimeter ditch that runs along the northern boundary of NAS Moffett Field (Figure 6.1-1). Water is pumped from that ditch to an off-site canal which leads to Guadalupe Slough. The total length of Marriage Road Ditch is slightly more than 1/4 mile. The ditch was constructed prior to 1947 and originally extended across Macon Road to the Hangar 2 and 3 aprons. Storm drains in and around Hangars 2 and 3 discharged into the ditch. An estimated 150,000 to 750,000 gallons of mixed hazardous waste containing waste oils, solvents, fuels, detergents, paints, paint strippers, and hydraulic fluids were disposed of in the storm drains from the 1940s to the 1970s.

One UST (#53) exists at the southeast corner of Marriage and Patrol roads. The tank is a 500-gallon unleaded gasoline tank for use by the golf course physical plant and was closed following discovery that the tank was leaking (ERM-West, 1987). The tank was removed by the Navy in June 1990.

The general topography of Site 3 is relatively flat, ranging from 1 to 2 feet below msl to approximately 5 feet above msl. Due to the flatness of Site 3, there are few natural surface drainage systems. Drainage of surface runoff is accomplished almost exclusively by the storm drains and small ditches which drain into Marriage Road Ditch. Marriage Road Ditch has been cut to -5 to -6 feet msl, which is the lowest elevation at Site 3. Portions of the ditch are lined with concrete.

6.2 FIELD INVESTIGATION

The investigation activities at Site 3 included the following:

- Continuous coring and geophysical logging of deep borings
- Installation of monitoring wells in the B and C aquifers
- Analysis of ground water samples from existing and new wells
- Surface and shallow subsurface soil sampling along Marriage Road Ditch

- Water level monitoring
- Soil gas surveying
- Analysis of soil samples.

6.2.1 Geophysical Borings

Five geophysical borings, GB-13 through GB-17, were drilled in and around Site 3. Locations of the borings are shown on Figure 6.1-1. The borings were continuously cored and geophysically logged. Borings and geophysical logs were presented in the December 1988 Quarterly Report (IT, 1988e). The suite of geophysical logs completed in each boring included natural gamma, 6-foot lateral and point resistivity, and spontaneous potential. Caliper logging of the borings was also conducted. Geophysical borings (GB) 13, 14, 15, and 16 were advanced to a depth of 252 feet and GB-17 to a depth of 257 feet.

6.2.2 Soil Gas Survey

A gas survey was conducted at Site 3 to help define the extent and source of chlorinated and petroleum hydrocarbon gases in the vadose zone. A total of nine transect lines: TL-7, TL-8, TL-9, TL-14A, TL-14B, TL-15, TL-28, TL-39, and TL-44 were surveyed for the Site 3 investigation. The soil gas survey is discussed in greater detail in Section 1.6 of the Quarterly Report for December 1988 (IT, 1988e) and Section 1.5 of the March 1989 Quarterly Report (IT, 1988b).

The location of these transect lines and the survey results are shown in Figure 6.2-1. Results of the survey are discussed in Section 6.4.

6.2.3 Soil Borings

Nine soil borings were completed in Marriage Road Ditch. One boring was placed about every 250 linear feet. The borings were used to obtain vadose zone soil samples which were collected from depths of 0.2 and 3 feet.

6.2.4 Ground Water Monitoring Wells

A total of seven ground water monitoring wells were completed during this phase of study. Four wells were completed in the A aquifer [W03-12(A2), W03-13(A2), W03-22(A2), and W03-23(A1)]; two three in the B aquifer [W03-14(B2)

and W03-15(B3)] and one in the C aquifer [W03-16(C)]. Boring logs, including well construction details, were presented in the March 1989 Quarterly Report (IT, 1989b).

The A1-subaquifer well was screened from 10 to 15 feet, A2-subaquifer wells were screened at depths from 43 to 53 feet, the B-aquifer wells were screened from 61 to 88 feet bls, and the C-aquifer well from 168 to 173 feet bls. Table 2.3-2 gives the installation summary of wells installed at the site and Figure 6.1-1 shows the location of each well, including previously installed wells by EMCON and ESA.

Well W03-22(A2) was installed at the northeast end of the east-west channel that parallels Patrol Road. The well was intended to monitor ground water migrating toward the channel. Well W03-23(A1) was installed downgradient from Tank 53 to monitor possible tank leaks. Wells W03-14(B2), W03-15(B3), W03-15(B3), and W03-16(C) were drilled to determine if there is downward movement of contaminants. Wells W03-12(A2) and W03-13(A2) was drilled to determine if there is downward and horizontal movement of contaminants.

6.2.5 Soil Samples

Soil samples for chemical analyses were collected from all soil borings and ground water monitoring well borings. Samples were collected from 1-, 3-, and 5-foot depths, and from a 10-foot depth or above the saturated zone.

Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The analytical results of all soil samples are summarized in the March 1989 Quarterly Report (IT, 1989b). Summary data tables are presented in Appendix C of this report.

6.2.6 Ground Water Samples

Ground water samples were collected and analyzed for VOCs, BNAs, PCBs, metals, TDS, pH, specific conductance and major anions. The analytical results can be found in August 1989 and November 1989 Quarterly Reports (IT, 1989c; IT, 1989d). A summary compilation of all ground water data is provided in Appendix D of this report.

6.2.7 Water Level Measurements

Water level measurements were taken from new and previously installed A, B, and C aquifer monitoring wells. The monitoring wells previously installed included ESA and EMCON wells W03-01(A1), W03-02(A1), W03-03(A1), W03-08(A1), W03-11(A1), W03-04(B2), W03-07(B2), and W03-09(B2). Measurements were taken monthly from August 1988 to October 1989. Data from these wells were used to construct potentiometric surface maps of the A aquifer on a quarterly basis. These maps are presented in Appendix B. Hydrographs of the Site 3 well water levels are presented in Appendix A of this report.

6.3 HYDROGEOLOGY

6.3.1 Site Geology

The stratigraphy of Site 3 is similar to other sites with an interfingering of fine- and coarse-grained alluvial, marine, and estuarine deposits. The stratigraphic units are Pleistocene to Holocene in age but no distinctive time stratigraphic horizons have been identified.

Boring logs indicate, in the upper 50 feet, material consists of moderately graded, gravelly-sand which is locally discontinuous and a relatively continuous very fine grained and moderately graded silty to clayey sand. This material is interbedded with a medium brown, plastic, silty clay. A section of medium brown, plastic, silty clay marks the transition to thicker more laterally continuous units. This silty clay is relatively thin at the north end of the site (GB-17) and thickens to about 10 feet to the south.

Below the silty clay is a thick sequence of interbedded sands and silty clays which is about 150 feet thick. From about 50 feet to 105 feet bls is a sequence of medium brown to gray, moderately plastic clays and silty clay interbedded with a medium grained, soft, silty to clayey sand which becomes more sandy toward the west end of the Site (GB-13 and GB-15). Below this strata is a continuous, 40-foot-thick zone of gray brown to gray green, soft to moderately stiff, very plastic, clay to silty clay which thins slightly toward the center and western portions of the site. Directly below this clay is a fine-grained silty sand and medium-grained sand which appears to vary from 10 to 20 feet thick.

The last part of this sequence starts with a relatively thick (65 feet), continuous, blue gray to gray green, stiff to very stiff, plastic, clay to silty clay. Within this thick sequence of clay is a relatively continuous, 10-foot-thick sequence of predominantly fine to medium grain sand. Below the thick clay is a sequence of interbedded sands and clays which are in excess of 800 feet thick.

Figure 6.3-1 is a fence diagram that illustrates the interpretation of the site stratigraphy. Geologic cross-section CC' (Figure 3.3-4) shows a detailed interpretation of stratigraphy based on geophysical log data.

6.3.2 Hydrology

Surface Water

The topographic relief of Site 3 is nearly flat with a slope from south to north and a maximum elevation of about 9 feet. Surface water drains from the site through local drainage ditches and pipes into Marriage Road Ditch. Water in Marriage Road Ditch flows in a northerly direction into a drainage channel which parallels Patrol Road. Water from this channel is then pumped over a dike into an east-west canal that discharges into Guadalupe Slough and the Bay. Ponding of water occurs in open ditches and artificial ponds that exist on the golf course. Overflow from the ponds flows via pipes to various drainage ditches.

Vadose Zone

The vadose zone lies from the ground surface to 6 to 7 feet bls. The lithology of the vadose zone ranges from native clayey soil to reworked surface material. The construction of a golf course at the site has required extensive rework of the surface material.

Ground Water

The subaquifers at Site 3 are the A1, A2, B2, and B3. The A1-subaquifer is locally discontinuous resulting in the A1 and A2-subaquifers acting as a

single hydrologic unit. Additionally, the A2/B2 aquitard is thin in the northern portion of the site indicating a possible leaky condition between the A2 and B2-subaquifers.

The A aquifer extends from the ground water surface to a depth of about 50 feet bls and consists of the A1 and A2-subaquifers. This approximation is based on monitoring well logs and geophysical borings GB-14 and GB-15. Saturated zones consist of moderately graded, gravelly sand interbedded with silty clay. Appendix B of this volume shows the potentiometric surface maps for Site 3 for four quarters (December 1988, March 1989, June 1989, and September 1989). The potentiometric surface is from about -2 feet msl in the southern portion of the site, to -5 feet msl at the northern edge of the site.

The B aquifer is a thick sequence of sands and silty clays which extends from 60 feet bls to 135 feet bls. The aquifer can be separated into two subaquifers; the B2 and B3, which become more distinct with depth. The approximation of depth is based on lithologic descriptions from W03-16C, electric log interpretations and lack of core recovery from boring into or through the B aquifer.

The C aquifer is a very thick sequence of sands and gravels that extends from about 175 feet bls to in excess of 250 feet bls (GB-14 and GB-15). Because of the single boring into the C aquifer, no potentiometric surface map was constructed. W03-16(C) is a flowing artisan well.

Hydrographs illustrating monthly water level changes are included in Appendix A. Seasonal water level variations are approximately 0.5 feet and is attributed to a variation of seasonal precipitation.

6.4 NATURE AND EXTENT OF CONTAMINATION

6.4.1 Sources

The primary source of potential contamination at Site 3 is the Marriage Road Ditch. A second source is an organic solvent plume associated with Sites 4, 6, and 7 that appears to have migrated onto the site.

Previous investigations drilled several soil borings and installed a number of monitoring wells. No unusual concentrations of chemicals were found in sediment samples taken from the ditch except for cadmium (6-9.5 mg/kg), lead (51-220 mg/kg), and zinc (110-200 mg/kg) (ESA, 1986a). Trace amounts of toluene (0.025 - 0.127 mg/kg) were detected in a well boring sample at 35 feet bls. Ground water samples contained a wide variety of VOCs at trace levels varying from 0.004 to 0.06 mg/l.

6.4.2 Review of Chemical Analyses

Soils

A total of 39 soil samples were analyzed for organic and inorganic compounds. VOCs and base-neutral acid extractable compounds detected in the soil samples from 1-, 3-, and 5-foot depths are presented in Tables 6.4-1 through 6.4-4. The most frequently detected compounds were the common laboratory contaminants acetone, 2-butanone, toluene, and methylene chloride. In most cases, each sample was associated with method blank contamination. In the following discussion, compounds will be discussed only where they are above quantitation limits or where the compounds are not found in the associated method blank.

The most common organic contaminant group found was phthalates. Twenty out of 39 samples contained detectable phthalate compounds. Phthalate compounds detected were bis(2-Ethylhexyl)phthalate, di-n-butylphthalate, and butylbenzylphthalate. Bis(2-ethylhexyl)phthalate, a common compound used in plastics was found at the 1-foot level in borings SB03-02 at 11,000 ug/kg, SB03-07 at 41,000 ug/kg, SB03-08 at 3,500 ug/kg, and W03-22(A2) at 370 ug/kg. The compound was found in one sample, SB03-04 at 750 ug/kg, at the 3-foot depth but was not found at the 5-foot depth. Since bis(2-ethylhexyl)phthalate is present in the soils and ground water in most places on NAS Moffett Field, it is not certain if it is derived from a local source.

TPHC was found in four borings in samples taken from 0.2 foot bls and 1.2 feet bls. SB03-03 contained 110 mg/kg, SB03-05 at 420 mg/kg, SB03-07 at 240 mg/kg, and SB03-09 at 700 mg/kg. TPHC was not found in soil samples taken from borings for monitoring wells.

Aroclor-1260 was found in boring SB03-05 at 420 ug/kg, SB03-06 at an estimated amount of 430 ug/kg, SB03-07 at 630 ug/kg, and SB03-08 at 230 ug/kg. PCBs are common in transformers and electrical starters. The source of this low level contamination is not presently known.

Soil samples were compared to baseline concentrations presented in Table 3.2-1. The following metals and nonmetals were not detected above baseline in any soil samples:

- Arsenic
- Mercury
- Sodium
- Silver.

A review of soils data indicates that most inorganics are present within typical ranges for local soils. Elevated inorganics were detected almost exclusively within the 1-foot sampling depth, which is representative of materials deposited in and along Marriage Road Ditch. Inorganics exhibiting concentrations of note in the 3-foot depths are barium, beryllium, calcium, chromium, lead, copper, manganese, nickel, and zinc. Barium, beryllium, cadmium, calcium, cobalt, copper, iron, and nickel were noted at the 5-foot depth.

Barium was detected above the NAS baseline of 220.4 mg/kg in samples from the 1-, 3-, and 5-foot depths. The barium level from the 1-foot depth in W03-16(C) was 531 mg/kg and 330 mg/kg in SB03-02. The remaining samples ranged from 223 mg/kg to 299 mg/kg.

Beryllium was found above USGS baseline (<1 mg/kg) in 23 samples. However, the compound was found above the NAS baseline in only four samples. SB03-02 has the highest level (6.5 mg/kg) from the 0.2-foot depth. SB03-04 was 4.4 mg/kg at the 0.2- and 3-foot levels and SB03-03 was 5.2 mg/kg at the 1.2 foot depth.

Cadmium was detected above the NAS baseline in six samples. Concentrations ranged from 4.2 mg/kg to 18.2 mg/kg and were found only in 0.2-foot depth, except in SB03-07 where there was 4.2 mg/kg at the 3-foot depth.

Chromium was detected above the Hetch-Hetchy baseline of 60 mg/kg in 17 soil samples. Concentrations ranged from 60.7 to 153 mg/kg and were found above baseline at various depths at several locations. SB03-02 contained 153 mg/kg at 0.2-feet and SB03-03 was 103 at 0.2-feet and 95.7 mg/kg at 1.2-feet. The remaining wells and borings were below the NAS baseline except SB03-04 at 86.2 mg/kg and SB03-05 at 80.2 mg/kg. None was greater than the USGS baseline value of 2,000 mg/kg.

Copper was found above the MV18 baseline of 44 mg/kg in seven soil samples. Three samples from 0.2 and 1-foot samples were above the NAS baseline of 56.7 mg/kg and ranged from 63.8 mg/kg to 79.8 mg/kg. The concentration range of all soil samples is 22.5 mg/kg to 79.8 mg/kg, below the USGS baseline of 700 mg/kg.

Iron was detected above NAS baseline in three soil samples. SB03-02 (0.2 foot) and SB03-03 (1.2 foot) had 53,800 mg/kg and 42,300 mg/kg, respectively. Well W03-22(A2) contained 96,800 mg/kg at the 5-foot depth. All samples are below the USGS baseline value of 100,000 mg/kg.

Lead was detected above the NAS baseline of 28.3 mg/kg in 14 soil samples. Soil samples from the 0.2-foot of SB03-02, -03, -05, and -06 were elevated and ranged from 260 mg/kg to 490 mg/kg. Lead was found above the MV-18 baseline (54 mg/kg) at the 3-foot depth in SB03-07 (138 mg/kg) and W03-15(B3) (116 mg/kg).

Magnesium was detected in four samples above the NAS baseline of 19,567 mg/kg and ranged from 19,800 mg/kg to 31,800 mg/kg. No samples were above the USGS baseline of 100,000 mg/kg.

Manganese was detected in two samples above the NAS baseline of 721 mg/kg. SB03-02 and W03-23(A1) contained 1,470 mg/kg and 1,200 mg/kg, respectively. No samples were above the USGS baseline of 7,000 mg/kg.

Nickel was above the Hetch-Hetchy baseline of 47 mg/kg in 33 soil samples. The concentration range is 47.8 to 107 mg/kg. These values do not exceed the USGS baselines of 700 mg/kg; however, two samples exceed the NAS baseline of

88.5 mg/kg. SB03-02 contained 107 mg/kg at 0.2 foot and SB03-03 contained 92.8 mg/kg at 1.2 feet.

Zinc was found above the NAS baseline of 104 mg/kg in five of the nine soil samples from the ditch. Concentrations ranged from 69.6 mg/kg to 359 mg/kg; most of the high concentrations were from the 0.2-foot level. The 1-foot sample from W3-22(A2) (163 mg/kg) was also above the NAS baseline, but not significantly.

Soil Gas Surveys

Six soil gas survey lines were completed, with a total of 71 soil gas samples taken. Soil gas samples analyzed by GC for chlorinated hydrocarbons and BTX compounds showed limited VOCs (TCE at 47 ppb, DCE at 240 ppb, and benzene at 440 ppb). The primary locations of total ionizable compounds at Site 3 were TL7-AS5 which had a level of 1,191.8 ppm of total VOCs, TL14B-AS28 which contained 1,505 ppm, and TL14A-AS21, 1,923.5 ppm. Figure 6.4-1 shows the areal distribution of soil gas sampling. The results of GC analysis are included in Table 6.4-8. Twenty-eight sampling locations had readings that were less than 1 ppm. The source for the elevated soil gas has not been identified.

Ground Water

Acetone, methylene chloride, and toluene were the three most common compounds detected in ground water from A, B, and C aquifers (Tables 6.4-5 through 6.4-7). These were almost always associated with method blank contamination. Those detections that were not associated with method blank contamination were below or only slightly above quantitation limits or listed as an estimated value.

Bis(2-ethylhexyl)phthalate and Di-n-octyl phthalate were found in only one sample, well W03-12(A2) at 250 µg/l and W03-22(A2) at 59 µg/l, respectively. The C aquifer well W03-16(C) showed only a single observation of bis-(2-ethylhexyl)phthalate at 45 µg/l.

Well W03-01(A1) showed consistent detections above quantitation limits of four volatile organics:

1,1-dichloroethane (7 µg/l), 1,2-dichloroethane (20 µg/l),
1,2-dichloroethenes (total) (14 µg/l), TCE (15 µg/l).

Well W3-23(A1), downgradient of Tank 53, also showed consistent detections of 1,2-DCA (13 to 20 µg/l). Other than those above, organic compounds were not found above quantitation limits in any other Site 3 wells.

The source of the VOCs is not presently known; however, it is believed the source is from Site 7, the north end of Hangar 2.

Elements that are naturally occurring constituents of seawater (Table 3.5-2) were found in high concentrations in monitoring well samples. Additionally, several elements which occur naturally in high concentrations in soils are also high in ground water. These include calcium, iron, magnesium, manganese, potassium, and sodium. These elements had concentration ranges typical of station ground water and will not be discussed.

Several other metals were detected in ground water samples above quantitation limits from A1, A2, and B2 subaquifer wells. These include: aluminum, antimony, mercury, lead, and zinc. None of these elements were detected consistently in any of the wells however, and the detections are not considered indicative of ground water contamination. Concentration ranges and the number of detections are shown in Tables 6.4-5 through 6.4-6. Metals above quantitation limits were not found in the B3- and C-aquifer wells.

From these data, it can be concluded that ground water quality degradation at Site 3 is limited to that resulting from seawater intrusion and the encroaching Site 7 plume. Soils collected along Marriage Road Ditch contain significant amounts of metals within the upper 3 feet, which suggests a potential source of ground water contamination.

7.0 ABANDONED WASTEWATER HOLDING PONDS - SITE 4

7.1 DESCRIPTION AND HISTORY

Site 4 encompasses the former industrial wastewater holding pond that was located north of Hangar 3 and west of the existing ponds (Figure 7.1-1). The former pond was unlined and received about 15 million gallons of wastewater from aircraft washing, equipment maintenance, and operations in Hangars 2 and 3 from 1968 to 1978 (NEESA, 1984). The wastewater was held in the pond, treated, and discharged to the sanitary sewer. As much as 35,000 gallons of hazardous materials, including toluene, MEK, dry cleaning solvent, paint sludge, paint stripper, Freon 113, TCE, TCA, carbon remover, ethylene glycol, fuel, and oil was discharged to the pond either directly or as components of wastewater.

7.2 FIELD INVESTIGATION

The investigation activities at Site 4 include:

- Continuous cores and logs from geophysical borings
- Installation of monitoring wells
- Ground water and soil chemical analyses
- Water level measurements.

The data gathered from the activities provide baseline information on ground water quality in the B3 and C subaquifers and the monitoring of potential downward contaminant migration.

7.2.1 Geophysical Borings

Three borings: GB-18, GB-19, GB-20 were cored and geophysically logged for stratigraphic and lithologic information. Geophysical borings GB-18 and GB-19 had total depths of 252 feet and GB-20 had a total depth of 257 feet. Down-hole geophysical logging was conducted using natural gamma, spontaneous potential, point resistivity, and lateral resistivity tools. The borehole vertical diameter profile was measured using a caliper tool. Locations of geophysical borings are shown in Figure 7.2-1, and geophysical logs are presented in

Appendix J of the December 1988 Quarterly Report (IT, 1988e). Boring logs of the geophysical and the monitoring wells are included in Section 3.0 of Appendix I in the March 1989 Quarterly Report (IT, 1989b).

7.2.2 Ground Water Monitoring Wells

Three ground water monitoring wells were installed at the site. A fourth was abandoned when no aquifer material was encountered. The following is a construction summary:

	<u>Total Drilled Depth (feet bls)</u>	<u>Screened Depth (feet bls)</u>	<u>Aquifer Monitored</u>	<u>Aquifer Material</u>
W04-7(C)	186	169-171	C	Sandy gravel
W04-8(C)	160	147-152	C	Clayey sand
W04-9(B3)	111	94-99	B3	Clayey silty sand
W04-11(A)	99	abandoned		

Subsurface materials penetrated at W04-11(A) were entirely silty sandy clay or silty clay. No water-bearing materials suitable for installation of a monitoring well were encountered. Six A-aquifer monitoring wells were installed at Site 4 in previous investigations. These include five A1 subaquifer wells [W04-01(A1), W04-02(A1), W04-03(A1), W04-04(A1), and W04-05(A1)] and one A2 subaquifer well [W4-6(A2)].

Well construction details of borings installed during Phase 1 are included in Section 3.0 of Appendix I in the March 1989 Quarterly Report (IT, 1989b).

7.2.3 Soil Samples

Soil samples for chemical analyses were collected from the vadose zone at approximately 1-, 3-, and 5-foot depths from all monitoring well borings. Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. Preliminary analytical data are available in Appendix B of the August 1989 Quarterly Report (IT, 1989c) and summary data compilations are presented in Appendices C and D of this report. An interpretation of soils data follows in Section 7.4.

7.2.4 Ground Water Samples

Four quarters of ground water samples were collected and analyzed for VOCs, pH, specific conductivity, minor anions, TDS, metals, BNAs, and TPHC.

Analytical data for all monitoring wells are available in Appendix B of the August 1989 (IT, 1989c) and November 1989 (IT, 1989d) Quarterly Reports and the February 1990 Quarterly Report (IT, 1990). A summary compilation of detected contaminants is given in Appendix D of this report and an interpretation of the data follows in Section 7.4.

7.2.5 Water Level Measurements

Water levels were monitored in A-aquifer wells W04-02(A1), W04-03(A1), W04-04(A1), and W04-06(A2); in B-aquifer well W04-09(B3); and in C aquifer wells W04-08(C), and W04-07(C). The water level measurements occurred monthly from November 30, 1988 until October 26, 1989. The water level of well W04-07(C) was above land surface during the entire time period. Water level measurements are shown on hydrographs in Appendix A of this report.

7.3 HYDROGEOLOGY

7.3.1 Site Geology

The interfingering and interbedding of fine-grained aquitards and coarse-grained aquifers at Site 4 is complex, highly variable, and exhibits limited lateral continuity of individual aquifers, especially the A aquifer which extends to about 55 feet bls. An example of this variability is provided by boring GB-19 and wells W04-08(C) and W04-11(A) which are located less than 16 feet apart. The lithologic well log of boring GB-19 shows interbedded silty sand and sandy clay in the 7- to 42-foot interval. The natural gamma ray log indicates coarse-grained sediments occur at 8 feet, 16 to 17 feet, 19 to 20 feet, and 26 to 30 feet bls. These coarse-grained sediments (aquifers) were not found in the adjacent wells, even though sample recovery in well W04-11(A) was excellent. The converse is true in wells adjacent to geophysical borings GB-18 and GB-20: that is, in W04-09(B3) and W04-07(C), there is lateral continuity of the sediment.

7.3.2 Hydrology

Surface Water

There are no natural surface water features at Site 4. Precipitation either infiltrates into the soil or drains northward into the ditches adjacent to Marriage Road and Macon Road. Because Sunnyvale soils present at this site are poorly drained and saturated, infiltration of precipitation is not expected to be rapid. Two new flux ponds have been constructed and are presently in use. A study was completed in 1989 by the Navy.

Vadose Zone

The vadose zone at Site 4 extends to about 13 feet bls (well W4-11(A) abandoned) and is predominantly composed of silty clay. The near surface part of the vadose zone consists primarily of reworked surface material used for road, auto, and aircraft parking. The area to the east and north is presently a golf course.

Ground Water

The A aquifer extends to about 55 feet bls at Site 4. A-aquifer materials consist of clayey and silty fine- to coarse-grained sands, clayey and silty gravel, and gravel. These sands and gravels range from 2 feet to 12 feet in thickness, based on geophysical logs, and are interbedded with the finer grained silts and clays. A-aquifer sediments range from tan and medium brown, light olive gray to olive gray, to dark gray. Boring logs in Appendix I of the December Quarterly Report (IT, 1988e) contain detailed descriptions of A-aquifer materials. Geophysical logs are in Appendix J of the December Quarterly Report (IT, 1988e).

At Site 4 A1 aquifer materials are found within the upper 20 feet of all borings and wells except W04-08(C) and W04-11(A). A2 aquifer materials occur at 35 to 45 feet in boring GB-18, and in wells W04-06(A2), W04-07(C), and W04-09(B3). The A2 subaquifer was not found in boring GB-19 or wells W04-08(C) and W04-11(A). Gamma ray logs and lithologic logs indicate that coarse-grained intervals, probably aquifers, also occur at 27 to 36 feet bls in borings GB-18 and GB-20. Typical depth intervals of aquifers and aquitards at NAS Moffett Field are presented in Table 3.4-1.

At most borings and wells at Site 4 the A2-B2 aquitard consists of silty clay. The upper surface of the aquitard is found within the 42- to 54-foot bls interval. The base of the aquitard ranges in depth from 52 feet bls in GB-19 to 70 feet bls in W04-09(B3). The stratigraphy at Site 4 is shown in geologic cross section CC' (Figure 3.3-4).

The A2-B2 aquitard is silty clay, clay, or silty sand. The gamma and resistivity logs show intervals from 2 to 10 feet thick with responses typical of fine-grained material alternating with coarse grained material.

The B aquifer interval occurs between 60 and 110 feet bls, with water-bearing intervals consisting of beds of sand and interbedded gravel and silty clayey sand. These intervals range from 2 to 15 feet thick and make up the B2 and B3 subaquifers.

Coarse-grained, water-bearing strata occur in the B2 aquifer in the 60- to 80-foot bls interval and consists of silty sand, silty clay, sand, and interbedded sand gravel and clay. The B2/B3 aquitard is silty clay, or interbedded silty clay and clay.

Water-bearing strata in the B3 subaquifer occurs from the 85- to 110-feet bls interval and include silty and clayey sands, gravel, and sandy clay. The B/C aquitard was encountered in most borings and wells from about 110 to 150 feet.

Information concerning the C subaquifer at Site 4 was provided by geophysical borings GB-18, GB-19, and GB-20 and wells W04-07(C) and well W04-08(C). As shown by boring and geophysical logs (Appendix I and J of the December 1988 Quarterly Report, IT, 1988e), a thin, coarse-grained aquifer occurs in the top ten feet underlain by a ten foot thick clay. Coarse-grained intervals are common in the main part of the C aquifer at Site 4. These intervals consist of sand and gravels up to 15 feet thick, although most are less than 5 feet thick. The individual water-bearing strata are interbedded with silty clay, sandy clay, and clay.

No aquifer tests were conducted at Site 4 during the Phase 1 study. Aquifer tests conducted by EMCON and Associates (1983a and 1983b) at Site 4 indicate transmissivities of about $1.2 \text{ cm}^2/\text{sec}$ and a storativity of about 0.001.

Water levels in wells W04-03(A1), W04-04(A1) and W04-06(A2) are generally within 0.1 foot elevation of each other. These wells have water level elevations that ranged from -1.0 feet in January 1989 to -1.95 feet in August 1989. Water levels in well W04-02(A1) ranged from -1.5 feet to -2.2 feet during the same time period.

For the period of November 1988 to November 1989, hydrographs of A-aquifer wells show the highest ground water levels in January. From March 1989 until August 1989 ground water levels declined 0.45 to 0.55 feet, and from August 1989 until November 1989 water levels increased about 0.2 feet.

Potentiometric surface contour maps of the A and B aquifers underlying Site 4 are presented in Appendix B of this report.

7.4 NATURE AND EXTENT OF CONTAMINATION

7.4.1 Sources

The primary source of potential contamination to soil and ground water at Site 4 is the contents of the former unlined industrial wastewater holding pond located west of the existing ponds. The pond was reported to have received as much as 35,000 gallons of hazardous materials including toluene, MEK, dry cleaning solvent, paint sludge, paint stripper, Freon 113, TCE, TCA, carbon remover, ethylene glycol, fuel, and oil.

7.4.2 Review of Chemical Analysis

Soils

A total of 13 soil samples were collected from monitoring well borings from depths ranging from 1 to 6.5 feet bls. Concentrations of organic compounds detected in the soil samples are presented in Tables 7.4-1 to 7.4-4. Only VOCs were found in Site 4 soil samples. The most frequently detected compounds were common laboratory contaminants (methylene chloride and acetone). In most cases when methylene chloride and acetone were detected in a

sample, they were also detected in associated method blanks.

At the 1-foot level, the only other compound detected was chloroethane (13 µg/l) in well W04-08(C). Toluene (13 µg/l) was detected at the 5-foot level [Well W04-07(C)]. No organic compounds were detected at the 3-foot level.

A summary of metals and inorganic compounds detected in soils from Site 4 is presented in Tables 7.4-1 to 7.4-4. Background soil samples were not specifically collected for this study. Baseline ranges for inorganic constituents were determined as discussed in Section 3.1. The following discussion focuses on constituents detected above the baseline range. Naturally occurring inorganic constituents within the soils (aluminum, calcium, sodium, potassium, and magnesium) are present at levels typical for the station and will not be discussed further.

Barium was found above NAS baseline (220.4 mg/kg) in six samples with a maximum concentration of 238 mg/kg. Although barium was found at the 1- and 3-foot depths, the levels are considered to be within an acceptable range.

Beryllium was found in eight samples that ranged from 1.2 mg/kg to 2.3 mg/kg. This range is above the Hetch-Hetchy baseline (0.8 mg/kg) but below the NAS baseline (3.7 mg/kg).

Chromium was found above the Hetch-Hetchy baseline (60 mg/kg) in only one sample W04-09(B3) (81.7 mg/kg) at 3-feet. This measurement is only slightly above the NAS baseline (76.5 mg/kg) and is considered to be within the natural variation of soils.

Cobalt (maximum value of 20.1 mg/kg) was found below all baselines except NAS baseline of 18.6 mg/kg. This level is considered to be within an acceptable range.

Copper was found in two samples which were above the Hetch-Hetchy, MV-18, and NAS baselines. The NAS baseline is 56.7 mg/kg and copper was found at 58.3 mg/kg and 60.5 mg/kg. These levels are considered acceptable.

Iron was found in one sample at 298,000 mg/kg. The sample was from the 5-foot depth of W4-9(B3) which had normal levels of iron in shallower samples. The reported concentration far exceeds all baselines and is unconfirmed by other samples.

Nickel was found in all samples above the Hetch-Hetchy baseline (47 mg/kg), but below the NAS baseline (88.5 mg/kg). The metal ranged from 65.5 mg/kg to 80.6 mg/kg, which appears to be within an acceptable range.

Silver was found in one sample at 4.8 mg/kg. This level exceeds the Hetch-Hetchy and MV-18 baselines, but is below the NAS and USGS baselines.

From the above data it can be concluded that soil quality degradation due to site activities is not discernable.

Ground Water

Samples were taken from wells W04-02(A1), W04-03(A1), W04-04(A1), W04-06(A2), W04-07(C), and W04-09(B3). Samples were analyzed for BNAs, VOCs, PCBs, metals, and nonmetals. Summary statistical evaluations of analytical results are presented in Tables 7.4-5 to 7.4-6. Summary data are presented in Appendix D of this report.

The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each detection was associated with method blank contamination. Methylene chloride was found in all analyses.

Well W04-04(A1) contained elevated levels of organics which includes:

<u>Compound</u>	<u>Range (µg/l)</u>
1,1-dichloroethane	5 to 27
1,2-dichloroethenes (total)	69 to 490
Carbon tetrachloride	5
Chloroform	29
Tetrachloroethene	5 to 7
Trichloroethene	16 to 24

Well W04-03(A1) contained 1,2-dichloroethenes (totals) that ranged from 14 µg/l to 16 µg/l and trichloroethene that ranged from 12 µg/l to 14 µg/l. Well W04-02(A1) contained trichloroethene which ranged from 37 µg/l to 51 µg/l. One sample from W04-06(A2) contained carbon tetrachloride at 34 µg/l.

The probable source of these VOCs is from Tank 43 or the drainage system at Site 7. Continued work during Phase II is planned at Sites 4 and 7 to delineate the source of this organic contamination in the ground water.

Samples from Phase I ground water monitoring wells W4-9(B3) and W4-7(C) were analyzed for metals and nonmetals. Several metals were consistently above the quantitation limit. These elements and compounds are presented on Tables 7.4-5 to 7.4-6. Naturally occurring inorganic constituents in the soils (aluminum, calcium, sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has contributed to the natural degradation of the water quality. The naturally occurring inorganic compounds associated with soil and seawater will not be discussed in this text.

Metals found in ground water samples above quantitation limits include arsenic and manganese. Arsenic was found in three out of seven samples from W04-09(B3) (two samples and one duplicate) at 10.2 to 11.2 µg/l. Manganese was found in W04-07(C) from 36.4 µg/l to 44 µg/l and in W04-09(B3) from 59.1 µg/l to 70.5 µg/l. The detections of arsenic were low level and not consistent and are not considered indicative of ground water contamination. Manganese has been detected at the low levels found at Site 4 and at other sites on the station and these levels are considered typical of station ground water. The occurrences of these two metals indicate that no source is evident to impact the ground water.

8.0 FUEL FARM AREA - SITE 5

8.1 DESCRIPTION AND HISTORY

Site 5 is separated into a northern site, located in the triangular area bordered by Macon Road, Patrol Road, and the golf course, and a southern site, bounded by Patrol Road on the east, runway aprons to the south and west, and Hangar 3 to the north (see Figure 8.1-1).

This area contained the main fuel facilities for NAS Moffett Field for approximately 15 years from the 1950s to the 1960s. Water and fuel were pumped into French drains during routine tank drainage. The exact location of the drains and the quantities of fuel dumped in the drains are unknown, although two open vertical pipes have been located at the site.

Several large JP-5 tanks and one waste oil tank exist in the northern portion of Site 5 (ERM-West, 1986a). Eight large underground tanks containing diesel fuel, jet fuel, and unleaded gasoline exist in the southern portion of Site 5.

8.2 FIELD INVESTIGATION

The investigation activities conducted at Site 5 are summarized as follows:

- Continuous coring and geophysical logging of borings.
- Installation of monitoring wells in the A and B aquifers.
- Analysis of water and soil samples for chemical constituents.
- Soil gas surveying.
- Water level monitoring.

The data gathered from the investigation at Site 5 allow an assessment of the extent of contamination that occurred due to chemical discharge into the French drains and possible leakage into the ground water from various tanks. The locations of other areas of spills were also evaluated in the Site 5 investigation.

8.2.1 Geophysical Borings

Three geophysical borings (GB-21, GB-22, and GB-23) were drilled at Site 5

from June 30 to August 23, 1988. The locations of the borings are shown in Figure 8.2-1. GB-21 was located on the northern boundary of Site 5 (north), GB-22 between the northern and southern fuel farms, and GB-23 south of Site 5. Each boring was drilled to the following depths; GB-21 to 232 feet bls, GB-22 to 248 feet bls, and GB-23 to 252 feet bls.

Geophysical methods used for logging these borings were natural gamma, point resistivity, six-foot lateral, spontaneous potential, and caliper. Each boring was logged to its total depth except GB-21. Due to a cave-in of the boring, GB-21 was logged only to 210 feet bls.

The GB borings were continuously cored for lithologic description and correlation with the E-logs. Because of the unconsolidated nature of some of the subsurface materials, one hundred percent recovery of the core was not accomplished. Boring and geophysical logs are included in Appendices I and J, respectively, of the December 1988 Quarterly Report (IT, 1988e).

8.2.2 Monitoring Wells

Thirteen monitoring wells were drilled and installed at Site 5. At the northern location, three wells, W05-06(A1), W05-14(A1), and W05-15(A1), were completed in the A1 subaquifer, one well, W05-04(A2), was completed in the A2 subaquifer, and one well, W05-05(C), was completed in the C aquifer. The first boring for W05-06(A1) was abandoned as no significant aquifer material was encountered. At the southern location, five wells - W05-09(A1), W05-10(A1), W05-16(A1), W05-17(A1), and W05-18(A1) - were completed in the A1 subaquifer and three wells - W05-07(A2), W05-08(A2), and W05-19(A2) - were completed in the A2 subaquifer. No B aquifer wells were installed at Site 5. The locations of all the wells are shown on Figure 8.2-1.

The A aquifer wells were screened to depths ranging from 8 to 55 feet, and the C subaquifer well from 145 to 155 feet. Screen intervals and well construction details are shown on Table 2.3-2.

Wells W05-04(A2), W05-05(C), and W05-06(A1) were installed to characterize soil and ground water contamination and the stratigraphy of the northern portion of the site. Wells W05-10(A1), W05-07(A2), W05-08(A2), and W05-09(A1)

were installed to characterize soil and ground water contamination and the stratigraphy of the southern portion of the site. Six additional A aquifer wells W05-14(A1) through W05-19(A2) were installed downgradient of potentially leaking tanks. Also, three of the above A aquifer wells W05-06(A1), W05-07(A2), and W05-09(A1) help monitor tanks. A list of tanks and the wells which were installed to monitor them are summarized below:

<u>Well No.</u>	<u>Tank No.</u>
W05-06(A1)	26
W05-07(A2)	8,9
W05-09(A1)	18,27
W05-14(A1)	12,13
W05-15(A1)	10,11
W05-16(A1)	4
W05-17(A1)	5
W05-18(A1)	6
W05-19(A2)	7

Boring logs and well construction details were presented in Appendix I in the December 1988 Quarterly Report (IT, 1988e).

8.2.3 Soil Gas Survey

A soil gas survey was conducted at Site 5 to help define specific source areas, refine well locations for Phase II, and approximate the extent of petroleum hydrocarbons. A total of seven transect lines - TL-10, TL-11, TL-12, TL-13, TL-16, TL-17, and TL-43 - were surveyed for the Site 5 investigation. The location of these transect lines and the survey results are shown in Figure 8.2-2. Selected soil gas stations were sampled for analysis by GC. These data are presented in Table 8.2-1. Results of the survey are discussed in Section 8.4. Soil gas survey methods are discussed in greater detail in Section 2.3.4.

8.2.4 Soil Borings

One soil boring, SB5-1, was drilled on the northern portion of the site (Figure 8.2-1) to a depth of 45 feet. This soil boring was intended to be monitoring well W05-06(A); however, no suitable aquifer material for screening was encountered. The boring was abandoned by backfilling with neat cement.

8.2.5 Soil Samples

Soil samples for chemical analysis were collected from each monitoring well boring at depths of approximately 1-, 3-, and 5-feet. Soil samples were analyzed for VOCs, pH, metals, BNAs, and TPHC. Preliminary analytical data are available in the March 1989 Quarterly Report (IT, 1989b). Summary data tables are included in Appendix C of this report.

8.2.6 Ground Water Samples

Six rounds of ground water sampling were completed for four quarters of monitoring. Ground water samples were analyzed for VOCs, pH, specific conductivity, major ions, TDS, BNAs, and TPHC. Preliminary analytical data are available in the March (IT, 1989b), August (IT, 1989c), and November 1989 (IT, 1989d) Quarterly Reports. Summary tables are included in Appendix D of this report.

8.2.7 Water Level Measurements

Monthly water level measurements were taken from November 1988 through October 1989 for all Phase I wells. The measurements were collected for determining ground water gradient at the site, and to generate quarterly potentiometric surface maps. These maps are presented in Appendix B and the data are plotted on hydrographs included in Appendix A of this report.

8.3 HYDROGEOLOGY

8.3.1 Geology

Interpretation of lithologic and electric logs from three geophysical borings (GB-21, GB-22 and GB-23) provide a cross-sectional representation of the Site 5 geology from the surface to about 250 foot depth. The borings trace the site lithologies approximately 2,400 feet on a nearly north-south profile. Two of the geophysical borings (GB-22 and GB-23) are represented on the cross section depicted in Figure 3.3-4. This profile is parallel to the general ground water flow direction and to the depositional slope upon which the sediments were deposited.

The lithologic sequence at Site 5 as shown in Figure 3.3-4 is interpreted

primarily from the geophysical logs from these boreholes. The boring logs yield a somewhat less detailed representation of the lithologies. This may result from either the lack of core recovery for a given interval or the inherent limitations of a qualitative visual verses a quantitative geophysical method. The following discussion of the lithologies focuses on sequences of strata that corresponds to hydrologic units described in the hydrology discussion (Section 8.3.3). These units correspond to the A, B and C aquifers, their subunits, and the intermediate aquitard units as discussed in relation to other sites at NAS Moffett Field.

Geophysical borings GB-22 and GB-23 penetrate about 100 feet into the C aquifer and GB-21 was drilled 45 feet into the C aquifer. The characteristics of the geophysical log from the GB-21 is very similar to that of the other two borings (GB-22 and 23). The similarity of the geophysical log traces (resistivity and natural gamma) suggest that Geophysical Boring GB-21 intersects a correlatable section reflecting the same depositional sequence as the two deeper borings. This is apparent in the natural gamma log reflecting a strong consistency in clay content. The resistivity log shows a shift to higher resistive material in GB-21 boring reflecting a greater component of coarse, probably sandy material, on the bayward end of the depositional system.

The basal lithology in GB-22 and GB-23 consists of silts and clay with alternating layers of coarser materials, approximately 5-foot lenses, at depths between 230 and 190 feet bls. A major coarse grain material (probably sand) is seen between 170 and 190 feet bls in GB-23 and appears to thin to the north (GB-22). The coarse grained material (sand) of the C aquifer section in GB-21 is closer to the surface than in the two southerly borings. This yields a more resistive section although the general character of the natural gamma indicates a similar distribution of clay.

The C aquifer zone includes a low resistivity (silty material) unit at between 160 and 170 feet bls in GB-23. The lithology is interpreted from the sharp drop in resistivity without a corresponding increase in natural gamma response and lithologic log from cores. The natural gamma shows a more gradual increase in intensity indicating a gradual increase in clay content. The

natural gamma response reaches a local maximum at approximately 160 feet bls reflecting the top of the aquitard unit. The aquitard unit is a 10-foot thick clay which is consistent across Site 5 although the depth to the top of the unit is about 150 feet bls to the north (GB-21).

Above this is an upper unit of the C aquifer which is approximately 7 to 10 feet thick. The material appears to be sand, although the recovery of geologic core from this interval was poor and clay is indicated in the geologic log from GB-23. In spite of the poor recovery the geophysical logs strongly suggests the presence of aquifer material. The natural gamma and the resistivity logs indicate a very coarse sand or gravel with little clay.

The B aquifer unit is subdivided into two subunits: the B2 and B3 subaquifers. The aquitard between the B2 and the B3 aquifers is less distinct in the northern part of Site 5. The evidence for the presence and lithologies for each aquifer are discussed in greater detail below.

The C aquifer and the B3 subaquifer are separated by a thick (35 to 40 foot) aquitard consisting of silty clay to clay. Some local zones of sand are present and correlatable at about 135 feet bls in GB-23. The sand may be present at slightly shallower or nearly the same depths in GB-21 and GB-22. The lateral continuity of the aquitard across the site is good and the thickness is consistent across the site. The B3 subaquifer consists predominantly of coarse grain (sand) material from about 90 to 120 feet bls. The unit thins from 25 to 20 feet to the north (GB-21) and a clay-silt material replaces the coarse grained material (GB-23).

The B2/B3 aquitard is about 5 to 7 feet thick and occurs between 90 and 95 feet bls in GB-23. The aquitard represents a thin, 5- to 7-foot thick, clay, as indicated in the boring log. A sandy clay is seen in GB-23 but no separate unit is observed in the geologic logs from either GB-22 or GB-23. The geophysical log and core recovery from GB-21 do not indicate the presence of the B2/B3 aquitard unit. This aquitard may be absent or contain more coarse material in the northern part of the site. The geophysical logs show a fairly consistent coarse grained material for the B2 subaquifer. Cores recovered indicate silty clay but GB-21 shows fine grained sand. Geophysical logs and

the low core recovery of only silt and clay are indicative of a predominantly sand unit with silt and clay interbedded.

The B3 and B2 subaquifer units are generally composed of thick blocky sands with occasional clay interbeds. The individual sand units vary in thickness and grain size composition, but the B3 and B2 subaquifers appear to be laterally continuous.

The A and B aquifers are separated by a clay, the A2/B2 aquitard unit, that is well evidenced in the geophysical logs from all Site 5 geophysical borings. The top of the aquitard occurs from about 55- to 65-foot depths and has a consistent thickness of about 10 feet. The A aquifer units show less continuity with thinner strata and clay interbeds. This is common for the A aquifer across most of NAS Moffett Field. The definition of the A1 and A2 subaquifer is not straightforward. The top of the 5- to 10-foot thick A1/A2 aquitard occurs between 20 and 27 feet. It is a distinct clay at the north and south extremes of the site (GB-21 and GB-23) but is less obvious in the central GB-22 boring. GB-22 resistivity indicates a low resistivity unit without significant natural gamma response. This may represent a change in the aquitard material to a silt or a thin bed. A lower aquitard appears to be present in the central and northern portions of the site at about 40 feet bls although it may contain silt or is very thin.

The near surface material is highly variable with sand predominating in the south and central areas. Clay and silt predominant in the northern part of the site at depths less than 30 feet. The clay in the northern part of the site is further evidenced by boreholes in that area that were originally designed as A2 aquifer monitoring wells. Well W05-14(A1) and SB5-1 were not completed to the originally specified depths due to the lack of sufficient coarse-grained aquifer material. Well W05-14(A1) was completed in a thin sand zone at a depth of about 12 feet after being drilled to a total depth of 70 feet bls. Soil boring SB5-1 was originally intended to be the location of a monitoring well in the A1 aquifer zone. The boring was abandoned after being drilled to 45 feet bls. The lack of aquifer material in the A1 and A2 subaquifer is a departure from the normal sequence seen at NAS Moffett Field and may represent a boundary condition in the depositional system where channel

migration was restricted and mud flat or marsh deposition was predominant. The lack of sands could be of major importance to the hydrologic regime in the eastern part of the station.

8.3.2 Hydrology

Surface Water

Surface water on the northern part of Site 5 flows south to drainage ditches along Macon Road or north along Patrol Road. In the southern part of Site 5, surface water is collected in ditches along Macon and Patrol roads, or flows into storm drains at Site 13 which discharge into the Marriage Road Ditch.

Vadose Zone

Ground water was first encountered approximately 8 to 11 feet bls in Site 5 borings. The majority of the vadose zone materials are clays with some small lenses of sands. The sands within the vadose zone tend to be very wet or saturated.

Ground Water

Twelve of 13 Site 5 monitoring wells were installed in the A aquifer. Monitoring wells W05-07(A2) and W05-14(A1) were drilled as B aquifer wells; however no aquifer material was encountered. The wells were plugged back with bentonite cement grout and completed in the A aquifer. One well, W05-05(C), was completed in the uppermost coarse unit of the C aquifer.

The A1 and A2 subaquifers is Site 5 are comprised of 1- to 6-foot thick layers of sandy clayey gravel to clayey silty sand interbedded in silty clays. The A aquifer ranges from approximately 10 to 70 feet bls. Ground water was first encountered at 8 to 11 feet bls and rose to approximately 6 to 9 feet bls.

Three potentiometric surface contour maps for March 1989, June 1989, and September 1989 are presented in Appendix B of this report. The maps show a drop in ground water elevations from March through September (wet to dry season) of approximately 1.5 feet for all the A wells. The ground water in the A aquifer flows northerly with a gradient of approximately 0.3 percent.

Data on the B aquifer at Site 5 is limited to logs of the geophysical borings. Low core recovery and E-log character suggests the aquifer material is composed of 2- to 10-foot thick sands and gravels. In some locations (e.g., GB-22) only a few coarse grained units were present. The aquifer is composed of thick, discontinuous sands and gravels interbedded with sandy clay and ranges from 70 to 120 feet bls.

The top of the C aquifer is about 155 feet bls at Site 5. Approximately 100 feet of the aquifer zone was penetrated by geophysical borings, which bottomed at about 250 feet bls. The C aquifer is composed of thick sands and gravels. A review of the boring and electric logs suggest that several possible water bearing zones are within the 155 to 250 foot (bls) interval.

8.4 NATURE AND EXTENT OF CONTAMINATION

8.4.1 Sources

Sources for contamination at Site 5 include: above and below ground fuel storage tanks, French drains used to dispose of tank drainage, and a fuel station. Jet fuel (JP-5), diesel fuel, and unleaded gasoline have been stored in the tanks.

In the Initial Assessment Study (IAS), NEESA (1984) estimated that as much as 28,000 gallons of fuel could be present on top of the ground water at the site based on observations of fuel levels in wells. Compounds detected in soil samples included organic lead, alkenes, alkanes, benzenes, and alcohols.

Three A aquifer wells and three shallow borings were drilled during previous investigations. Ground water analyses from these wells were highly variable. Organic lead was not detected and volatile organic priority pollutants were generally below 0.2 µg/l. Alkanes were the predominant organics found, ranging from 60 to 200 µg/l in two wells.

8.4.2 Review of Chemical Analyses

Distributions of analytes detected above quantitation limits are shown in plates contained in Appendix E of this report.

Soils

Soil samples were collected during the drilling of the ground water monitoring wells. A total of 43 soil samples were analyzed for VOCs, metals, BNAs, and TPHC. Results of soil sample analyses are presented in summary tables in Appendix C. Statistical analyses are included in Tables 8.4-1 through 8.4-4.

Bis(2-ethylhexyl)phthalate was found in only three samples at levels above quantitation limits (330 mg/kg). The phthalate was present in the 1- and 5-foot samples from well boring W05-06(A1) at concentrations of 1,600 and 1,500 µg/kg. The 5-foot sample from well boring W05-15(A1) had 530 µg/kg.

2-methylnaphthalene was detected only in the 5-foot sample from W05-07(A2). The concentration reported is above the method quantitation limit, but is estimated at 1,100 µg/kg, due to interferences from TPHC. The probable source for this compound would be from aviation fuel. This compound is not included in Table 8.4-3 because of its estimated quantitation.

TPHC was detected in two samples from well W05-07(A2) at 5- and 6.5-feet depths at concentrations of 1,000 and 290 mg/kg, respectively. The probable source is aviation fuels. The soils indicate fuel contamination at one location at Site 5; W05-7(A2). This well is downgradient of Tanks 8 and 9.

Metals and ion concentrations were compared to the baseline levels presented in Table 3.2-1.

As discussed in Section 4.4, several elements of common rock forming minerals occur naturally at variable concentrations in soils. These elements include:

- Aluminum
- Barium
- Cadmium
- Calcium
- Iron
- Magnesium
- Manganese
- Potassium
- Selenium
- Sodium.

Except for calcium, which was not found above baseline levels, Site 5 samples

showed concentrations of these elements over NAS baseline levels. The concentrations were not significantly elevated over the averaged NAS baseline ranges and are considered natural.

Other metals and nonmetals were found above one or more of the four baselines and are discussed below:

Antimony was found above the USGS baseline of 10 mg/kg in five samples from various depths in four wells/borings; the highest concentration was 17 mg/kg. The slightly elevated levels of antimony are not considered an indication of contamination. Three other samples, from W05-08(A2), were also above the NAS baseline of 54.4 mg/kg with concentrations ranging from 60.9 to 91.2 mg/kg. It is unclear why antimony would be elevated at this location.

Arsenic was found above the Hetch-Hetchy baseline of 6.3 mg/kg in two samples from Site 5. The 5-foot from well boring W05-06(A1) and the 6.5-foot samples from W05-07(A2) each had a concentration of 8 mg/kg. This level is not above other baselines for arsenic.

Beryllium occurred above the Hetch-Hetchy baseline of 0.8 mg/kg in 32 samples. The range of concentrations of beryllium at Site 5 is from 1.0 to 5.8 mg/kg. Eight samples were also above the NAS baseline level of 3.7 mg/kg; however, the high concentration of less than 1.5 times the baseline is not indicative of anthropogenic contamination.

Chromium was found above the Hetch-Hetchy baseline of 60 mg/kg in 32 samples from Site 5. The range of concentrations is from 49.2 to 197 mg/kg. Of these sample concentrations, only 14 were above the MW-18 baseline of 72 mg/kg and 10 were above the NAS baseline of 76.5 mg/kg. The 1-foot sample from W05-08(A2) had the high concentration of 197 mg/kg, slightly more than twice the NAS baseline. The next highest concentration was 98.6 mg/kg. These data are not considered indicative of contamination.

Cobalt was detected above the NAS baseline of 18.6 mg/kg in seven samples from various depths in six well borings. The highest concentration was from the 1-foot sample from W05-08(A2) at 33.8 mg/kg. This is less than twice the NAS

baseline. Other samples were only slightly above the baseline and are not above the USGS baseline.

Copper was detected above the MW-18 baseline of 44 mg/kg in 15 samples from various depths and well borings at Site 5. Six of these were slightly above the NAS baseline of 56.7 mg/kg although none was above the USGS baseline. The range of concentrations for copper is from 21.7 to 77.5 mg/kg and is considered natural.

Lead was detected above the NAS baseline of 28.3 mg/kg in two samples. One was slightly above at 28.8 mg/kg. The other was also above the Hetch-Hetchy and MW-18 baselines with a concentration of 224 mg/kg from the 3-foot samples from W05-15(A1). This is nearly 8 times the NAS baseline and may be indicative of lead contamination associated with leaded fuel tank leakage. However, organic analyses of samples from this boring did not show fuel components or TPHC.

Mercury was detected above the Hetch-Hetchy baseline of 0.1 mg/kg in only two samples. The one-foot sample from W05-17(A1) and the five-foot sample from W05-04(A2) each had a concentration of 0.2 mg/kg. This is only slightly above the Hetch-Hetchy baseline and is not above the other three baselines.

Nickel was found above the Hetch-Hetchy baseline of 47 mg/kg in 39 samples, but above the NAS baseline of 88.5 mg/kg in only six samples. The range of concentrations of nickel is 40.7 to 106 mg/kg. This range is within the USGS baseline, and only slightly above the NAS baseline.

Vanadium was found above the NAS baseline of 78.2 mg/kg in seven samples from various depths in five well borings. The high concentration is 115 mg/kg, about 1.5 times the NAS baseline. This level is not significantly above the baseline and is considered a natural variation.

Zinc was found above the NAS baseline of 104.1 mg/kg and the Hetch-Hetchy and MW-18 baseline of 110 mg/kg in three samples. The 3-foot sample had a concentration of 113 mg/kg, the one-foot sample from W05-07(A2) had a concentration of 130 mg/kg, and the 1-foot sample from W05-15(A1) had a concentration of 188

mg/kg. These concentrations were not above the USGS baseline and are not significantly over the NAS baseline.

Although several metals and nonmetals occur above the baselines at Site 5, none occurred at significant levels. All are considered natural occurrences with one exception. One sample indicated lead contamination in soils. Further investigation in this area (proposed for Phase II) should identify contamination to soils by fuel.

Soil Gas Surveys

A soil gas survey was conducted along six transect lines, with a total of 37 soil gas samples taken (Figure 8.4-1). Fourteen samples were analyzed by GC for chlorinated hydrocarbons and benzene, toluene, ethyl benzene and xylene (BTEX).

The primary chlorinated hydrocarbons detected at Site 5 were 1,1-DCA, cis-DCE, 1,1,1-TCA, and TCE. The highest levels detected were from TL-10 AS1 where cis-DCE and TCE were 16,700 and 47,000 ppb respectively. The source for these compounds is most likely from solvents used on site. In some cases the occurrence of these compounds is associated with BTEX compounds indicating that the solvents may have been mixed with waste oil and disposed of in the french drains.

High levels of BTEX compounds were found in the soil gas surveys. Sampling location TL-16 AS1 detected m-,p-xylene and o-xylene at levels of 204,000 ppb and 156,000 ppb respectively. Other locations with high levels of BTEX compounds are TL-10 AS1 (benzene and toluene), TL-10 AS2 (toluene), TL-10 AS3 (benzene and xylene), TL-10 AS8 (toluene and xylene), and TL-13 AS3 (toluene). The sources for these compounds is most likely from aviation fuel.

Elevated soil gas concentrations were found in three areas near the above ground fuel tanks at the northern end of Site 5 (Figures 8.2-2 and 6.2-1) where there was a known fuel spill. Soil gas constituents in these areas were predominantly fuels (BTEX). A fourth area of elevated soil gas was found east of Site 5. Soil gas constituents here were predominantly chlorinated VOCs. This latter soil gas plume may be from dumping of cleaning solvents used in

area operations.

Ground Water

Six rounds of ground water samples were collected from eight A1 and four A2 subaquifer wells and from one C aquifer well. Samples were analyzed for VOCs, BNAs, TPHC, metals, and major anions. No organic compounds were detected consistently (50 percent or more of samples from each well) in any of the Site 5 wells except acetone and methylene chloride. Acetone and methylene chloride were detected in samples from nearly all wells; however, the occurrences were nearly always associated with blank contamination, or were at levels below quantitation limits. The range of concentrations for acetone was 10 to 31 $\mu\text{g/l}$ (plus one sample at 290 $\mu\text{g/l}$ discussed below) and 5 to 36 $\mu\text{g/l}$ for methylene chloride.

In the A1 subaquifer wells, 4-methyl-2-pentanone was detected one time each in W05-6(A1) at 16 $\mu\text{g/l}$, in W05-14(A1) at 36 $\mu\text{g/l}$, and twice in W05-16(A1) at 10 and 15 $\mu\text{g/l}$. TPHC was detected above quantitation limits twice in W05-06(A1) at 0.32 and 300 mg/l , and in W05-16(A1) at 300 mg/l . Bis(2-ethylhexyl) phthalate was detected above quantitation limits in one sample from W05-09(A1) at 65 $\mu\text{g/l}$, and in one sample from W05-10(A1) at 210 $\mu\text{g/l}$. Concentration ranges of compounds detected above quantitation limits and the number of detections are shown in Table 8.4-5. The distribution of these compounds are shown in Plate E-13. These infrequent occurrences of organics are not indicative of aquifer contamination.

Similar occurrences of organics were found in A2 subaquifer well samples. Methylene chloride and acetone were found in nearly all samples at low levels but in association with method blank contamination or below quantitation limits. Acetone was reported in one sample from W05-07(A2) at 290 $\mu\text{g/l}$ with associated blank contamination, but in the sample duplicate acetone was found below quantitation limits (5 $\mu\text{g/l}$). Also, of the eight samples from this well (six rounds and two duplicate samples) five had acetone with blank contamination noted, and three of these were below quantitation limits.

Semivolatiles (BNAs) found in A2 subaquifer samples above quantitation limits and without associated blank contamination were limited in occurrence: bis(2-

ethylhexyl)phthalate was found in one sample from W05-04(A2) at 12 µg/l, and chrysene was found in one sample from W05-08(A2) at 12 µg/l.

Six rounds of sampling from the C aquifer well W05-05(C) showed occurrences of methylene chloride and acetone similar to the A aquifer samples. The only other organic compound found above quantitation limits was toluene which was detected in one sample at 10 µg/l. As with occurrences of organic compounds in the A aquifer samples, these limited occurrences are not indicative of C subaquifer contamination. A summary of the chemicals found in samples from the C aquifer is presented in Table 8.4-6.

Ground water samples were collected from eight A1 and five A2, subaquifer wells. The samples were analyzed for metals and nonmetals for all rounds of sampling and for major anions for four rounds of sampling. The Site 5 area is within the area of saltwater intrusion mapped by Iwamura (1980) and consequently, the shallow wells show high concentrations of common seawater ions, though the intrusion is not as severe at Site 5 as at some of the northernmost areas of the station. The concentration ranges of calcium, magnesium, and sodium for the A aquifer are shown in Table 8.4-5. Potassium is also a common seawater component; however, all samples had concentrations below the quantitation limit of 5,000 µg/l except for one which had a concentration of 5,080 µg/l.

Two other metals were detected consistently (50 percent or more of the samples from each well) in all Site 5 wells. Iron was found at concentrations ranging from 104 to 1,630 µg/l. These levels are below the background range reported by the DWR (Table 3.5-1). Manganese was found at concentrations ranging from 33.9 to 1,080 µg/l. These levels are above the reported background of 410 µg/l, however, the levels are common at NAS Moffett Field and may be elevated above background due to the typical composition of soils derived from ultrabasic to basic rocks such as those existing in the source rock area.

Selenium was detected in five of seven samples from well W05-08(A2) at a concentration range of 12.5 to 17 µg/l. These levels are slightly above the quantitation limits of 5 µg/l and well below the background level of 140 µg/l reported by the DWR (Table 3.5-1). The occurrence of selenium consistently in

one A2 well at this site and not in other wells, particularly not in A1 wells, is difficult to explain. Further investigation (Phase II) may provide more information on selenium distribution at Site 5.

Two other metals, cadmium and mercury, were detected only one or two times in each of several wells. Cadmium was detected one time each in W05-17(A1) and W05-18(A1), and twice in W05-08(A2). The concentration range is from 5.2 to 6.1 $\mu\text{g/l}$, only slightly above the quantitation limit of 5 $\mu\text{g/l}$. Mercury was detected one time each in five wells [W05-04(A2), W05-07(A2), W05-08(A2), W05-09(A1), and W05-15(A1)] at a concentration range of 0.2 to 1.2 $\mu\text{g/l}$, and twice in W05-10(A1) and W05-14(A1) at a range of 0.33 to 0.9 $\mu\text{g/l}$. The low level and limited occurrences of these metals are not considered indicative of aquifer contamination.

Analysis of major anions showed the presence of four anions which are common in ground water and seawater. These anions and their concentration ranges are:

- Bicarbonate 260 to 530 mg/l
- Chloride 15 to 160 mg/l
- Nitrate 0.40 to 7.6 mg/l
- Sulfate 5.5 to 260 mg/l.

The TDS concentrations ranged from 310 to 920 mg/l. These ranges are typical of groundwater at the station.

The C aquifer well samples were analyzed for the same parameters as other Site 5 wells. Concentrations of the common seawater elements were considerably lower than those of the A aquifer wells as expected, since this aquifer has not shown similar seawater intrusion. The concentration ranges, shown in Table 8.4-6, are within the background ranges presented by the DWR (Table 3.5-1) with the exception of one occurrence of potassium which was above background. The concentrations are only slightly above those found in the C aquifer well at Site 10 (Table 3.5-1) which is considered a deep background well for the station.

Similar to the A aquifer wells, manganese was the only metal detected consis-

tently in the C aquifer. The concentration range was 71 to 132 ug/l. This is twice the C aquifer background well levels, but is not inconsistent with B wells farther north and is within the DWR background range.

Two other metals were reported only one time each above quantitation limits. Lead was reported in one sample at 7.5 ug/l, just above quantitation limits of 5 ug/l and zinc was reported one time at 38.6 ug/l, also only slightly above quantitation limits of 20 ug/l. These limited and low level occurrences are not considered representative of ground water contamination.

Major anions in samples from the C aquifer well had generally lower concentration ranges than the shallower aquifer (Table 8.4-6). The detected ions and their concentration ranges are:

- Bicarbonate 200 to 220 mg/l
- Chloride 19 to 23 mg/l
- Sulfate 22 to 24 mg/l.

Total dissolved solids concentrations ranged from 300 to 350 mg/l. These levels are within the background ranges reported by the DWR (Table 3.5-1).

In summary, results of sample analysis for Site 5 do not indicate contamination of ground water by organic or inorganic constituents. This is not an unexpected finding based on the results of soil sampling and the geology of the area which shows a predominance of clay in the shallow zone. These shallow clays have apparently inhibited migration of any tank leakage down to the A1 and A2 subaquifers. Most of the Site 5 wells were placed in the farfield relative to the tanks and unidentified contamination may be present in the shallow clays adjacent to tanks and in possible shallow, discontinuous sand lenses. The Phase II program will help define any contamination which may exist closer to the Site 5 tanks.

9.0 RUNWAY APRON - SITE 6

9.1 DESCRIPTION AND HISTORY

The Runway Apron disposal site is located adjacent to the former aprons north and east of Hangar 3 (Site 7) and south of the wastewater surface impoundments area (Site 4). The location of Site 6 is shown on Figure 9.1-1. The site is relatively flat with an elevation about 5 feet msl. The site was paved over in 1979 during enlargement of the original apron. It is estimated that 120,000 to 600,000 gallons of hazardous waste from aircraft maintenance - including solvents, oils, fuels, paints, and paint strippers - were disposed of at this site from the 1940s to the 1970s (NEESA, 1984). Today the site is used mainly as an automobile parking area for Naval personnel.

9.2 FIELD INVESTIGATION

Seven wells and several soil borings installed during prior studies have confirmed the presence of volatile organics in site soils and ground water (ERM-West, 1986). The extent of contamination was not determined during these studies and five of the wells installed appear to monitor nonaquifer materials. Phase I of this study did not include installation of additional monitoring wells or drilling of soil borings. Phase I activities were restricted to:

- Collecting and analyzing ground water samples for organic and inorganic chemicals from two existing wells that monitor aquifer material [W06-02(A2) and W06-03(A1)].
- Measuring water levels in two existing monitoring wells [W06-02(A1) and W06-03 (A1)].

9.2.1 Ground Water Samples

Four rounds of ground water samples were collected from two wells installed prior to the RI: W06-02(A2) installed by ESA and W06-03(A1) installed by EMCON. Wells W06-04(AX) and W06-05(AX), W06-06(AX), and W06-07(AX), which were installed by EMCON and Associates (EMCON, 1983), and well W06-01(AX), which was installed by ESA (ESA, 1986), were completed at a depth typical of the A aquifer but were not screened in aquifer material and are given an "AX" designation. These five "AX" wells were not sampled during the RI. Table 2.3-2 presents well data including total depth and screened interval for wells

W06-02(A2) and W06-03(A1). Preliminary complete ground water analytical data were presented in the March 1989 (IT, 1989b), August 1989 (IT, 1989c), November 1989 (IT, 1989d), and February 1990 (IT, 1990) Quarterly Reports. A summary data compilation is presented in Appendix D of this report.

9.2.2 Water Level Measurements

Water levels were measured monthly in A aquifer wells W06-02(A2) and W06-03(A1) from October 25, 1988 until October 26, 1989.

Hydrographs for each well are found in Appendix A. Potentiometric surface contours of the A aquifer for the east side of Moffett Field, which includes Site 6, can be found in Appendix B. The contour maps are presented for each quarter and are based on monthly water level data.

9.3 HYDROGEOLOGY

At Site 6, seven monitoring wells were drilled and installed by other investigators to define site stratigraphy, hydrogeology, and potential contamination of the ground water (Figure 9.1-1). The wells were part of previous studies by EMCON and Associates, (EMCON, 1983a, 1983b) and by ESA Inc. (ESA, 1986a).

9.3.1 Site Geology

No monitoring wells were installed at Site 6 during the RI; however, the geology at Site 6 is presumed to be similar to that at nearby Site 5, which is described in Section 8. North-south trending geologic cross section (C-C') on the east side of NAS Moffett Field goes through Site 6 and is shown in Figure 3.3-4.

9.3.2 Hydrology

Surface Water

There are no natural surface water features at Site 6. The two industrial waste water flux ponds north of the site are man-made surface water features. These ponds are clay-lined. There are no other man-made surface water features at Site 6.

Ground Water

No monitoring wells were installed during the RI. Locations of the aquifers in the Site 6 area are described in Section 7 (Site 4) and Section 8 (Site 5).

Monthly water level measurements were collected from wells W06-02(A2) and W06-03(A1) from October 1988 through October 1989. A hydrograph of these data is shown in Appendix A. The hydrograph shows that water levels in both wells increased from below sea level in October 1988 to an annual peak in January 1989. Water levels declined from January 1989 to August 1989 before gradually rising through the remainder of 1989 monitoring in a pattern expected in the A aquifer. Water levels in wells differ by less than 0.05 feet in elevation for the entire year except for one water level measurement obtained on September 26, 1989 from well W06-02(A2). This water level elevation is reported as -3.42 feet, about a 3-foot decrease from the August water level. This fluctuation is presumed to be a measurement error because adjacent well W06-03(A1) does not show a similar effect.

Potentiometric surface contour maps are shown in Appendix B. The maps show north to northeast flow of ground water underlying Site 6 toward Site 2. Site 6 wells are depicted on the potentiometric map for Site 7, plates 2, 5 and 8. The shallow ground water gradient is flat at less than 0.3 feet per 100 feet. Assuming Darcian flow, an average horizontal hydraulic conductivity of 3.3×10^{-6} ft/s, and a porosity of 30 percent, ground water velocity would be less than 1.0 ft/yr.

9.4 NATURE AND EXTENT OF CONTAMINATION

9.4.1 Sources

Runoff and intentional disposal at the former edge of the apron (before it was paved) are the primary sources of contamination at Site 6. Additionally, contaminated ground water from Sites 4, 5, 7, 13, 15, and 19 could possibly contribute to ground water contamination at Site 6.

9.4.2 Review of Chemical Analyses

Surface Water

No surface water samples were collected at Site 6.

Sediments and Soils

Sediment or soil samples were not collected from Site 6.

Ground Water

Ground water samples were collected quarterly for four quarters for a total of four samples per well, plus up to two duplicate samples. Wells W06-02(A2) and W06-03(A1) were the only wells sampled. Samples were analyzed for VOCs and general water quality parameters. The latter group was analyzed only twice at each well and included bicarbonate, carbonate, chloride, nitrate, sulfate, and TDS. A summary of analytical results is presented in Appendix D and summary statistics for compounds detected are shown in Table 9.4-1.

Only trace levels of 1,1-DCA and TCE ($<10 \mu\text{g/l}$) were detected above quantitation limits. In well W06-03(A1) 1,1-DCA was detected three times and in one duplicate sample, each time at laboratory detection limits (5 to 6 $\mu\text{g/l}$); TCE was detected only once, again at the limit (5 $\mu\text{g/l}$) of laboratory detection. 1,1-DCA was consistently detected in the A1-aquifer well indicating there may be trace levels of VOCs in this aquifer. The common laboratory contaminants acetone and methylene chloride were found sporadically in low concentrations but in association with method blank contamination. No other volatile organic compounds were found above quantitation limits in either of the A1 or A2 aquifer wells.

The general water quality in this area reflects lower concentrations of TDS, nitrate, and chloride than the majority of other sites under review. TDS ranged over a small interval of 200 mg/l to 890 mg/l. Chloride also was consistent in concentration in the two wells, ranging from 44 mg/l to 68 mg/l.

From these data, it can be concluded that ground water quality has been minimally impacted by site activities. Trace concentrations of chlorinated VOCs may represent the fringe of a plume emanating from Site 7.

10.0 HANGARS 2 AND 3 - SITE 7

10.1 DESCRIPTION AND HISTORY

Site 7 consists of Hangars 2 and 3 and the paved area surrounding the hangars, which lies to the west of Macon Road (see Figure 10.1-1). Ground surface elevations are approximately 10 feet msl. Unpaved areas at each corner of Hangars 2 and 3 were used to dispose of an estimated 120,000 to 600,000 gallons of paint, paint strippers, oils, solvents, fuels, hydraulic fluids, and other hazardous wastes. A power plant shop in the northeast corner of Hangar 3 disposed of chlorinated solvents, including TCE, through deck drains and on unpaved areas around Hangar 3. The hangars were constructed in 1942 and until 1978, hazardous waste that accumulated in the unpaved area surrounding the hangars flowed through deck drains to the Marriage Road ditch (NEESA, 1984). Several large fuel tanks and waste storage tanks were also present in the area. These tanks were recently removed by the Navy. A sump containing steam cleaning wastes is still present on the east side of Hangar 3.

10.2 FIELD INVESTIGATION

The purpose of the investigation at Site 7 is to characterize the chemical occurrences which have been identified, including what appears to be a plume of high solvent concentration near the northeast corner of Hangar 3 (near Tanks 2 and 43). A total of 21 borings were drilled previously at Site 7 to investigate stratigraphy, hydrogeology, and potential contamination of the vadose zone and ground water. Monitoring wells were installed in 16 of these borings as part of previous studies conducted by EMCON and Associates (EMCON, 1983a and b), ESA Inc. (ESA, 1986a), and consultants for the MEW companies. The Phase I investigation activities for Site 7 included:

- Continuous cores and geophysical logs from borings
- Installation of five monitoring wells in the A and C aquifers
- Installation of soil borings
- Ground water and soil chemical analyses
- Water level measurements.

10.2.1 Geophysical Borings

One geophysical boring (GB-24) was drilled to 257 feet bls and is located on the southwest corner of Hangar 2 (Figure 10.1-1). The boring was logged with resistivity, spontaneous potential, natural gamma, and caliper tools. The geophysical log is presented in the December 1988 Quarterly Report (IT, 1988e), and the boring log is presented in the March 1989 Quarterly Report (IT, 1989b).

10.2.2 Ground Water Monitoring Wells

A total of five ground water monitoring wells were completed for Phase I at Site 7:

- A aquifer wells W07-18(A2), W07-19(A1), W07-20(A2), and W07-21(A1)
- C aquifer well W07-16(C).

Well W07-16(C) is upgradient of the Site 7 hangars. Locations of the wells are shown in Figure 10.1-1. Boring logs with well construction details are presented in the March 1989 Quarterly Report (IT, 1989b). Well construction details are summarized in Table 2.3-2.

10.2.3 Soil Samples

Soil samples were collected from the vadose zone at approximately 1-, 3-, and 5-foot depths from all monitoring well borings. Soil samples were also collected from three shallow soil borings located at the corners of Hangars 2 and 3 (Figure 10.1-1). Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. Preliminary analytical data are available in the August 1989 Quarterly Report (IT, 1989c) and a summary data compilation is presented in Appendix C of this report.

10.2.4 Ground Water Samples

Six rounds of ground water samples were collected in four quarters from Phase I wells and analyzed for VOCs, PCBs, pH, conductivity, major anions, TDS, metals, BNA, and TPHC. Four rounds (four quarters) of ground water samples were collected from previously installed wells W07-01(A1), W07-04(A2), W07-08(A2), W07-13(A1), and W07-15(A2). Samples from these wells were analyzed for VOCs, ions, and TDS. A summary compilation of analytical results is given

in Appendix D of this report.

10.2.5 Water Level Measurements

Water level measurements were taken from the 10 sampled Site 7 monitoring wells (nine A aquifer wells and one C aquifer well). Measurements were taken monthly from February 1989 to October 1989. Data from the wells were used to construct quarterly potentiometric surface maps for the A aquifer and to determine hydraulic gradients. These maps are presented in Appendix B and data are plotted on hydrographs included in Appendix A of this report.

10.3 HYDROGEOLOGY

10.3.1 Site Geology

Monitoring well borings and geophysical borings provide data on the subsurface stratigraphy at Site 7 to a depth of 254 bls. This interval consists of Quaternary sedimentary deposits. The coarser-grained deposits - e.g. sand, silty and clayey sand, gravel, sandy and clayey gravel - can yield and transmit substantial amounts of water. Logs from GB-24 indicate that the maximum thickness of these deposits, 37 feet of gravel, is between 10 and 47 feet bls, and that a 50 foot deposit of clayey sand to sand lies between the 67 and 117 feet bls. Coarse-grained, estuarine sediments also occur as thin lenses, partings of sand and gravel, and as root casts in the silty and sandy clays.

The sands and gravels appear to represent channel deposits in this area due to their sharp vertical and areal definition. Information to interpret the areal distribution and continuity of coarse-grained sediments is most abundant for the upper 45 feet of the stratigraphic section. Data are less abundant for the 45 foot to 254 foot interval at Site 7. To assist the stratigraphic interpretation in the region along the east side of Hangar 3, data from Site 19 borings and wells have also been used for geologic review.

Sands and gravels are most abundant near the southwest corner of Hangar 2. Geophysical boring GB-24 and wells W07-01(A1) and W07-16(C) encountered gravel, gravelly sand, sands, and minor interbeds of silty and sandy clay. The coarse-grained sediments constitute up to about 90 percent of the 0 to 31

foot bls interval at GB-24 and W07-19(A1), and 50 percent of the same interval in W07-16(C). Wells W07-20(A2) and W07-18(A2) encountered less sand and gravel than borings near the southern corners of the hangars. In boring GB-29 (Site 19), about 80 percent of the interval between 0 to 30 feet bls consists of gravels but seven other borings located within a 100 foot radius of GB-29 have only minor sand and gravel - e.g. a few beds less than 2 feet thick - in the same interval. Further, the interval between 30 to 42 feet bls at well W07-18(A2) consists of sands and gravel whereas this interval in GB-29 is silty clay. Moving from the northeast corner of Hangar 3 to the northwest corner of Hangar 2, sand and gravel channel deposits become less abundant in the 0 to 25-foot interval. In well W07-19(A1) sand and gravels constitute approximately 40 percent of the section; in well W07-21(A1) sand constitutes approximately 20 percent of the section.

An interpretation of the stratigraphy at Site 7 is provided in geologic cross sections C-C' and D-D' (Figures 3.3-4 and 5). Resistivity characteristics of the units shown on these sections indicate that individual sand and gravel units are probably not continuous, but that the coarse-grained intervals extend across the site.

10.3.2 Hydrology

Potentiometric surface contours of the A aquifer for the east side of NAS Moffett Field can be found in Appendix B. Insufficient data are available to adequately contour the B and C aquifers. Contour maps are presented on a quarterly basis from monthly water level data. The hydrographs for each well are found in Appendix A.

Surface Water

Surface water runoff at Site 7 is collected by storm drains and diverted to the Marriage Road Ditch. Figure 10.3-1 shows the approximate location of storm drains at Site 7. Three storm drains run northwest adjacent and parallel to Hangars 2 and 3.

Vadose Zone

The vadose zone beneath Site 7 ranges from 4 to 10 feet bls. These depths are indicated on boring logs as the point where samples are wet, or where the

saturated zone was first encountered. In borings along the east side of Hangar 3 the maximum depths to the base of the vadose zone were between 9 and 10 feet bls. Along the south side of Site 7 maximum depth of the vadose zone was shallower at 4 to 8 feet bls. On the north end of Hangar 2 the depth of the vadose zone is 8 feet. The vadose zone consists of damp, black to light olive gray sandy clay and black, moist silty clay. The vadose zone in W07-13(A1) is damp silty clay and ranges from black to gray to gray brown. The vadose zone in W07-16(C), W07-18(A2), W07-19(A1), W07-20(A2), and W07-21(A1) includes sandy clay, silty clay, silty sandy clay, and sandy gravelly clays which range from black, bluish gray, brown, yellowish brown, to yellow.

Ground Water

The A aquifer extends to a maximum of 47 feet bls at Site 7. At Site 7, aquifer materials are found within the upper 20 feet in all borings and wells. A1 aquifer materials consisted of clayey and silty fine- to coarse-grained sands, clayey and silty gravel, and gravel. Based on boring logs and geophysical logs, these sands and gravels range from 2 to 37 feet in thickness and are interbedded with silty and sandy clays. The A1 subaquifer extends to about 25 feet bls. The A2 subaquifer material consists of gravel and coarse sand interbedded with clays. At Site 7, it occurs from about 30 to 60 feet bls.

The A/B aquitard consists of silty clay or sandy clay. The aquitard is about 10 to 12 feet thick and occurs between 55 to 70 feet bls.

Water-bearing intervals in the B aquifer are beds of sand, silty and clayey sand, and interbedded gravel, sand and clay. The coarse-grained units range from 2 to 20 feet in thickness. The thickest B subaquifer appears to occur in the B3 aquifer interval. The B2 subaquifer extends from 70 to 85 feet bls and the B3 subaquifer is from 90 to 110 feet bls.

Water levels in nine A aquifer wells were measured monthly from February 1989 through October 1989. The measurements were from W07-01(A1), W07-04(A2), W07-08(A2), W07-13(A1), W07-15(A2), W07-18(A2), W07-19(A1), W07-20(A2), and W07-21(A1). Hydrographs from these wells show the following general traits:

- Water levels rise during November and December with the greatest increase in December,
- Water levels fall in January but stabilize during February and March
- Water levels fall from April until September and then begin to rise.

Potentiometric surface maps of the A aquifer are included in Appendix B of this report.

The B/C aquitard was encountered in Site 7 borings at 110 to 155 feet bls. The top of the C aquifer was encountered at about 155 feet bls and its full thickness was not penetrated. The coarse-grained units in this interval are interbedded with silty clay, sandy clay, and clay.

Well W07-16(C) is the only C aquifer well at Site 7. Water levels in the well have been measured monthly. The hydrograph of the well shows:

- Water level rose during December and January, and then fell about 0.1 foot in February,
- During March water level rose about 0.25 foot and then stabilized for the next 3 months,
- During July and August the water level dropped about 0.1 foot and then began to rise in September.

Insufficient data are available to develop potentiometric surface maps of the B and C aquifers.

10.4 NATURE AND EXTENT OF CONTAMINATION

10.4.1 Sources

Hangars 2 and 3 appear to be sources of potential contamination to soils and ground water at Site 7 based on evidence reported by others prior to the RI. Spilled fuel and lubricant from aircraft and ground support vehicles was flushed from the paved surfaces into drains that emptied to Marriage Road Ditch. Chemicals used in shop operations in Hangars 2 and 3 were disposed of

at unpaved areas around the Hangars. Additionally, there were underground tanks located on the east side of Hangar 3, which may also have acted as sources (Site 19).

10.4.2 Review of Chemical Analyses

The following discussion presents a review of chemical data obtained from the various sampling activities. A summary compilation of soil and water analytical data is included in Appendices C and D of this report, respectively.

Soils and Sediments

A total of 26 soil samples from soil borings and monitoring well borings were analyzed for VOCs and BNAs. Samples were collected from 1-, 3-, 5-, and >5-foot depths. Statistical evaluations of the analytical results are presented in Tables 10.4-1 through 10.4-4. The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each detection was associated with method blank contamination. Methylene chloride was found in all samples, acetone was found in 14 samples, and 2-butanone was found in only one sample.

TPHC was found in two samples: one from the 1-foot depth in SB07-01 at 160 mg/kg and the other from the 3-foot depth in W07-20(A2) at 110 mg/kg. Neither TPHC nor oil and grease were found in any other soil borings or monitoring well borings.

Two other organic compounds were found in four other borings. W07-18(A2) contained total xylene of 16 µg/kg at the 2-foot depth, and 12 µg/kg at the 4-foot depth. Bis(2-ethylhexyl)phthalate was found in three wells and ranged from 760 µg/kg to 2,000 µg/kg in the 3- and 5-foot depths. This compound has been found in most soil samples collected on the station and does not appear to represent contamination at these concentrations.

The Site 7 data indicate that low levels of TPHC are present in soils near the Tank 2 former location and in shallow soils at the southeast corner of Hangar 3. Trace amounts of total xylenes may be present in soils at the south end of the Hangars 2 and 3 apron. Tank 2 has recently been removed by the Navy and data collected during removal may identify the extent of contamination.

Trace level contamination by total xylenes is limited to the unsaturated zone and the location is now covered by concrete.

A summary of metals and nonmetals detected in soils from Site 7 is presented in Tables 10.4-1 through 10.4-4. The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed in Figure 3.2-1. A review of soils data suggests that most inorganics are present below the established baseline. Elements that exceed the baseline are barium, chromium, copper, manganese, nickel, and zinc. Naturally occurring inorganic constituents within the soils - aluminum, calcium, sodium, potassium, and magnesium - will not be discussed as their concentrations did not exceed baselines.

Barium was found above baselines in two soil samples, the 1- and 3-foot depths from W07-21(A1) at 227 mg/kg and 278 mg/kg, respectively. These concentrations are slightly above the NAS baseline of 220.4 mg/kg and are probably representative of natural variation of soil chemistry.

Chromium exceeded the MV-18 baseline (72 mg/kg) only once, at 73.9 mg/kg. This occurrence was not above the NAS baseline or the USGS baseline and is not considered significant.

Copper was detected above the MV-18 baseline (44 mg/kg) in seven soil samples, with six of the occurrences below 73 mg/kg. SB07-02 contained 20,500 mg/kg at the 1-foot depth. The source of this single high number is not presently known. However, if brass particles or shavings are present in the soils, acid extractants used in sample analysis preparation may dissolve the brass, yielding an unrepresentatively high concentration of elemental copper in soils. The range of copper is only slightly above the NAS baseline (56.7 mg/kg), except for the single high occurrence, and is not considered excessive.

Manganese was detected above NAS baseline (721 mg/kg) at the 2-foot depth from W07-18(A2) at 1,010 mg/kg. This level is slightly above the NAS baseline and below the USGS baseline of 7,000 mg/kg.

Nickel was detected above Hetch-Hetchy baseline (47 mg/kg) in most soil samples from Site 7. The levels ranged from 34.4 mg/kg to 84.3 mg/kg. All samples were below the NAS baseline of 88.5 mg/kg.

Zinc was detected above all baselines in SB07-02. SB07-02 was reported to contain 8,660 mg/kg from a sample taken from the 1-foot depth. This is the same sample that contained high levels of copper, and as discussed, this concentration may indicate that brass shavings are present in the soils which would be leached by sample extraction processes, but not by ground water.

In summary, only copper and zinc were found at significantly elevated levels in soils. Both elevated occurrences were from the same sample and may indicate that brass shavings from equipment operations or cleaning are present in soils at this location (SB7-02). High concentrations may represent the leaching potential of sample extraction processes rather than the elemental concentrations in soils.

Ground Water

A total of 10 wells were sampled and analyzed in the Phase I investigation. Samples were taken from:

- W07-01(A1)
- W07-04(A2)
- W07-08(A2)
- W07-13(A1)
- W07-15(A2)
- W07-16(C)
- W07-18(A2)
- W07-19(A1)
- W07-20(A2)
- W07-21(A1).

Samples from wells W07-01(A1) through W07-15(A2) were analyzed for VOCs, ions, and TDS only. Samples from the Phase I wells [W07-16(C) through W07-21(A1)] were analyzed for BNAs, VOCs, PCBs, metals, and nonmetals, and TDS.

A summary of chemicals detected above quantitation limits in water is provided in Tables 10.4-5 and 10.4-6.

The most frequently detected compounds were the common laboratory contaminants acetone, and methylene chloride. In most cases, each detection was associated with method blank contamination. These compounds were found in all 10 wells that were sampled.

One well, W07-08(A2), contained elevated levels of organics which includes:

<u>Compound</u>	<u>Range (µg/l)</u>
1,1,1-Trichloroethane	5 to 8
1,2-Dichloroethane	5
1,2-Dichloroethanes (total)	14 to 25
Carbon tetrachloride	7 to 91
Chloroform	5 to 9
Tetrachloroethene	75 to 180
Trichloroethene	25 to 50

Well W07-08(A2) is immediately downgradient of the former Tank 43 location and the probable source of these VOCs is from that tank. The tank was recently removed by the Navy and sampling associated with the removal may confirm the source of this organic contamination in the ground water. Additional work is planned for Site 7 to assess the extent of this contamination.

Di-n-octyl phthalate was observed only once at 63.0 µg/l and is not considered indicative of ground water contamination.

Several metals were consistently above the quantitation limit. These elements and compounds are presented on Tables 10.4-5 and 10.4-6. Naturally occurring inorganic constituents in the soils (aluminum, calcium, sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has contributed to the natural degradation of the water quality. The naturally occurring elements and compounds will not be discussed in this text.

Metals found in the ground water samples above quantitation limits include arsenic, mercury, selenium, and iron. Arsenic was found in one sample from W07-16(C) at 10 µg/l. Mercury was found in one sample from W07-19(A1) at 0.7 µg/l. Selenium was found in four samples from W07-20(A2) at 5.0 µg/l to 7.8

µg/l. Iron was found in four samples and ranged from 105 µg/l to 2,060 µg/l. These levels are within the regional background range reported by the DWR (Table 3.5-1). Arsenic and mercury were found only one time each at different well locations and at very low levels, indicating that the detections are not indicative of ground water contamination. Selenium was found at only one location; however, it was found in four samples. It appears to be consistent within the one A2 subaquifer well but at a very low level. Selenium at very low levels was also found in a cross-gradient A2 subaquifer well at Site 5. As noted in Section 8.4, selenium is not found in nearby A1 subaquifer wells and the concentrations found are well below the background levels reported for the region by the DWR (Table 3.5-1).

11.0 WASTE OIL TRANSFER AREA - SITE 8

11.1 DESCRIPTION AND HISTORY

Site 8 is a fenced area located near Building 127, between Zook Road and McCord Avenue, where the off-site branch of the Defense Property Disposal Office (Alameda) (DPDO) maintained a 5,000-gallon waste oil tank from the 1940s until 1980 (Figure 11.1-1). Trucks from the shops and squadrons disposed of waste oil into a sump next to the road, from which the waste oil was transferred into the tank. The tank reportedly also received about 100 gallons/year of transformer oils, possibly containing PCBs, and 200 gallons/year of solvents. Oil was spilled onto the ground around the sump during oil transfer (NEESA, 1984). Both the tank and the sump were removed in 1981 (ESA, 1986a).

The waste oil transfer station and storage yard occupies approximately 20,000 square yards. The site is relatively flat and is between 6.5 and 8 feet msl. Most of the site east of Building 127 and the old sump area is a fine gravel expanse which currently serves as a storage yard for obsolete vehicles and other pieces of equipment. The storage yard is a probable source of shallow soil contamination (petroleum) resulting from the storage of vehicles.

11.2 FIELD INVESTIGATION

The investigation activities for Site 8 included:

- Continuous cores and geophysical logs from two geophysical borings
- Installation of five monitoring wells
- Installation of 13 shallow soil borings
- Ground water and soil chemical analyses
- Water level measurements.

11.2.1 Geophysical Borings

Geophysical borings were drilled adjacent to selected monitoring wells to provide continuous core sampling and borehole geophysical surveys. Two geophysical borings were drilled at the site (GB-25 and GB-26) (Figure 11.2.1). Geophysical borings GB-25 and GB-26 are 257 feet deep. Core sampling was

conducted in the geophysical borings to provide information on site lithologies. Core recovery was generally poor in the coarser grained (sand and gravel) lithologies and the geophysical logs are considered a more reliable lithologic indicator.

Down-hole geophysical tools included point and 6 foot normal resistivity, spontaneous potential, and natural gamma. Caliper logging of the borehole size was also conducted.

Geophysical logs are included in the December 1988 Quarterly Report (IT, 1988e). Boring logs are included in the March 1989 Quarterly Report (IT, 1989b).

11.2.2 Ground Water Monitoring Wells

Five monitoring wells were completed during Phase I. These completed wells are as follows:

- A-aquifer wells - W08-04(A1), W08-05(A2), W08-06(A2), and W08-02(A2)
- C-aquifer well - W08-03(C).

The five Phase I monitoring wells were installed in late 1988 and monitor the A and the C aquifers. Figure 11.2.1 shows the location of the monitoring wells. Monitoring wells vary in depth from 22.5 to 166.6 feet (Table 2.3.2).

11.2.3 Soil Samples

Shallow soil borings were drilled to collect near-surface samples for analysis of soil contamination. Phase I drilling and sampling included 13 soil borings (SB08-01 through SB08-13) to approximately 3 feet bls, with samples taken at 1- and 3-foot depths. The locations of the soil borings are shown on Figure 11.2-1.

Soil samples were also collected from all Phase I monitoring well borings at 1-, 3-, and 5-foot depths and were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. Analytical data for all soil samples collected at Site 8 can be found in the August 1989 Quarterly Report, Section 8.0 of Appendix B (IT, 1989c). A summary compilation of the analytical data is included in Appendix

C of this report.

11.2.4 Ground Water Samples

Ground water samples were analyzed for VOCs, PCBs, pH, specific conductivity, major ions, TDS, metals, BNA, and TPHC. Analytical data are available in the August 1989 (IT, 1989c), November 1989 (IT, 1989d), and the February 1990 (IT, 1990) Quarterly Report. A summary compilation of the analytical data is included in Appendix D of this report.

11.2.5 Water Level Measurement

Water level measurements were made monthly at Site 8 from December 1988 through September 1989. Six wells were on the measurement schedule and included five A aquifer and one C aquifer well. The water level hydrographs are presented in Appendix A of this report.

11.3 HYDROGEOLOGY

11.3.1 Site Geology

Exposed soils at the site range from light brown silty clay to dark organic rich clays. The surface soil in the surplus yard at the center of Site 8 is a light brown silty, sandy clay. This material was probably transported from off-site to provide a suitable surface for the facility operation. Boring logs indicate the presence of silt, sand, clay, and gravel immediately below the surface materials. North of the site the surface material is a dark organic rich clay different from the material in the surplus storage yard.

The sediments at Site 8 include marine and estuary deposits which are similar to deposits of the other sites. Coarse to fine grained textures are present. Site 8 is at the distal end of the depositional system and exhibits a larger component of estuarine sediments. The estuarine deposits consist of unconsolidated to partially consolidated plastic clay and silty clay, interbedded with coarse-grained channel deposits. An interpretation of the stratigraphy at Site 8 is shown in geologic cross-section A-A' (Figure 3.3-2). The stratigraphic units are Pleistocene to Holocene in age but no distinctive time stratigraphic horizons have been identified.

Electric logs from borings GB-25 and GB-26 indicate that the geologic section is composed of five distinct zones. The upper zone from near ground surface (10 feet) to 60 feet consists of alternating layers of coarse and fine grained materials consisting of clay, silt, sand, and some gravel. This zone corresponds to the A aquifer. Differences observed in the relative character of the geophysical logs indicate that the lateral continuity of any of these specific lithologies is uncertain.

An 8- to 10-foot thick clay layer at 60 feet bls marks the transition to thicker and more laterally continuous units. These thicker units occur in the interval from 70 to 115 feet bls and correspond to the B aquifer zone. This zone is characterized by a greater abundance of high resistivity material and a general increase in the natural gamma log responses. These responses indicate a greater clay content in the fine grain layers and a corresponding decrease in silt. The coarse-grained layers exhibit increased resistivity due to the increased fraction of sand and gravel. A number of the lithologic contacts are gradational.

The third zone is a thick, fine grain unit with low resistivity and high gamma response extending from 115 to 155 feet bls. The resistivity responses of the unit are uniformly quite low although some thin sand layers may be indicated by highly resistive layers. This interval of predominantly fine grained sediment corresponds to the B/C aquitard zone.

The deepest zone encountered by the geophysical borings extends from 155 to 257 feet. The natural gamma response over most of the interval is reduced, indicating a diminished clay content. The interval from 220 feet to the total hole depth of 257 feet shows a gradational increase in clay content with a corresponding decrease in overall sand content. This zone corresponds to the C aquifer zone.

11.3.2 Surface Water

The topography of Site 8 is nearly flat with a slope from south to north and a maximum elevation of 8 feet. Surface water drains from the site through storm drains and a drainage ditch that flows to the north-northeast. Ponding of water occurs in open ditches located south of the facility during periods of

heavy precipitation, creating a potential for ground water recharge.

Vadose Zone

The vadose zone lies from ground surface to 4 to 8 feet bls. The lithology of the vadose zone ranges from clay to sandy silty gravel. The presence of coarse-grained material in a matrix of fine grained clay may act as a preferential pathway for contaminants originating from the former oil sump and tank facility.

Ground Water

The subaquifers at Site 8 are the A1, A2, B2, B3, and C aquifer sequence. A subaquifers underlying the site consist of silty sand or sand and gravel deposits separated by relatively impermeable silts and clays. These sand and gravels vary in thickness and appear to be laterally discontinuous.

The A1 subaquifer extends from the top of the first coarse-grained unit to a depth of approximately 20 feet bls. This approximation is based largely on geophysical logs from GB-25 and GB-26. The lithology of the A aquifer is highly variable across the site. The presence of a 6-foot thick fine-grained unit at 20 feet bls marks the A1/A2 aquitard. This unit is correlatable with a similar unit at Site 9. The lack of a distinct clay and the similarity of water levels and seasonal variations indicate hydraulic interconnection between the A1 and A2 subaquifers.

The A2 subaquifer is observed from below the A1/A2 aquitard to a depth of 60 feet bls. The A2 subaquifer appears to be low in clay content and has thin coarse grained interbeds. The A2 subaquifer is bounded by the A2/B2 aquitard at about 60 feet. This aquitard consists of clay and is 6 to 8 feet thick.

The B2 aquifer is 20 to 26 feet thick (base at 88 to 94 feet bls) with a gradational increase in sand content with depth. The B2/B3 aquitard is present between 88 and 102 feet.

The B3 aquifer is between 16 and 18 feet thick and appears to have a substantial layered clay content. The B/C aquitard zone extends from about 115 feet to 155 feet bls.

The C aquifer extends from approximately 155 feet bls to the total depth of the holes (257 feet) and consists of interbeds of sand, gravel, and clay.

The water level measurements from the C aquifer [W08-03(C)] show no correlation between head levels in the A aquifer. Potentiometric surfaces at Site 8 are monitored by five wells in the A aquifer and one well in the C aquifer. The wells and screened intervals are listed on Table 2.3-2. Flow directions derived from September 1989 data indicate a north-northeast flow direction in the A aquifer. The difference in water levels in adjacent wells W08-06(A1) and W08-02(A2) is 0.04 foot. Hydraulic gradients across the site in the A aquifer are 0.0002.

Quarterly potentiometric surface maps of the A aquifer are included in Appendix B of this report. Monthly water level data are shown in the hydrographs for each well in Appendix A.

11.4 NATURE AND EXTENT OF CONTAMINATION

Monitoring well W08-03(C) is in an upgradient location to monitor possible deep aquifer contamination from upgradient sources. Site 9, off-base MEW Sources, and NASA are all upgradient of Site 8. W08-02(A2) was installed downgradient of the source area to monitor potential vertical contaminant flow in the A2 subaquifer. Two A-aquifer wells, W08-05(A2), and W08-06(A2), were installed downgradient of the source area while one well, W08-04(A1) was installed upgradient. The last three wells were installed to provide information on the lateral and vertical extent of the contamination. Previously installed wells W8-1(A2) (ESA) is upgradient of the former tank location and MEW-82(B2) is upgradient of the southwestern corner of Site 8. These wells were sampled during the Phase I investigation.

Soils and Sediments

A total of 36 soil samples were analyzed for VOCs, BNAs, TPHC, Oil and grease, PCBs, metals and nonmetals. Samples are collected from 1-, 2-, 3-, and 5-foot depths. A statistical evaluation of the analytical results is presented in Tables 11.4-1 through 11.4-3. The most frequently detected compounds were the common laboratory contaminants acetone, methylene chloride, and 2-butanone.

In most cases, each sample was associated with method blank contamination.

TPHC was found in two samples. One from the 1-foot depth in SB08-04 at 380 mg/kg and the other from the 1-foot depth in W08-06(A2) at 58 mg/kg. TPHC, and oil and grease were not found in any other soil borings or monitoring well borings.

PCBs were not found in the soil samples from Site 8.

Three other organic compounds were found in five samples from four borings. SB08-02 contained 2,000 µg/kg of benzoic acid at the 2-foot depth and 430 µg/kg of bis(2-ethylhexyl)phthalate at the 1-foot level. Bis(2-ethylhexyl)phthalate (900 µg/kg) was also found in SB08-09 at the 1-foot depth, and at 2,000 µg/kg at the 3-foot depth of SB08-11, however, the duplicate sample contained an estimated 43 µg/kg. Toluene was found at low levels (8 µg/kg) in the 3-foot depth sample from W8-04(A1).

A summary of metals and nonmetals detected in soils from Site 8 is presented in Tables 11.4-1 through 11.4-3. The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed in Table 3.2-1. A review of soils data suggests that most inorganics are present below the established baseline. Elements that exceed the baseline are; barium, beryllium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, vanadium, and zinc. Natural occurring inorganic constituents within the soils - aluminum, calcium, sodium, potassium, and magnesium - will not be discussed.

Barium was detected above NAS baseline of 220.4 mg/kg in 20 soil samples. The samples, taken from the 0.5-, 3-, and 5-foot depth, ranged from 233 mg/kg at 1-foot depth in SB08-09 to 305 mg/kg at the 1-foot depth in SB08-05. This range is slightly above the NAS baseline and below the USGS baseline.

Beryllium was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in 12 samples and above the NAS baseline (3.7 mg/kg) in three samples. W08-04(A1) contained 4.8 mg/kg at the 3-foot depth and 3.9 mg/kg at the 5-foot depth. W08-05(A2) contained 4.2 mg/kg at the 3-foot depth and 3.9 mg/kg at the 5-foot depth. These concentrations are not considered significantly elevated above

the NAS baseline.

Chromium was detected in 22 soil samples above the Hetch-Hetchy baseline (60 mg/kg) and ranged from 63.1 mg/kg at the 1-foot depth in SB08-12 to 82.6 mg/kg at the 1-foot depth in SB08-05. This range is within and slightly above the NAS baseline (76.5 mg/kg) and below the USGS baseline (2,000 mg/kg) and not considered significant.

Cobalt was detected in 11 soil samples above the NAS baseline of 18.6 mg/kg and ranged from 18.7 mg/kg at the 3-foot depth in SB08-10 to 23.5 mg/kg at the 3-foot depth in SB08-11. This range is slightly above the NAS baseline and not considered excessive.

Copper was detected above MV-18 baseline (44 mg/kg) in 23 soil samples and ranged from 44 mg/kg to 93.4 mg/kg except for SB08-01 which contained 21,600 mg/kg at the 1-foot depth and 10,000 mg/kg at the 3-foot depth. Except for the SB8-01 location, the range of copper is within or slightly above the Hetch-Hetchy baseline and the NAS baseline (56.7 mg/kg). The high concentrations in SB08-01 may be a result of leaching from brass during sample preparation (see discussion in Section 10.4).

Iron was detected above the NAS baseline (38,347 mg/kg) in five soil samples and ranged from 39,300 mg/kg to 43,600 mg/kg. This range is slightly above the NAS baseline and is not considered excessive.

Lead was detected above NAS baseline (28.3 mg/kg) in one sample from the 3-foot depth of SB08-05 at 61.6 mg/kg. This level exceeded the Hetch-Hetchy (48 mg/kg) and the MV-18 baseline of 54 mg/kg. The elevated concentration may be due to spillage of oils onto the ground at the nearby sump.

Nickel was detected above the Hetch-Hetchy baseline (47 mg/kg) in 35 soil samples from Site 8. The levels ranged from 50.9 mg/kg at the 1-foot depth in W08-06(A2) to 111 mg/kg at the 1-foot depth in SB08-09. Six samples were also above the NAS baseline of 88.5 mg/kg, however the maximum concentration (111 mg/kg) is not significantly above this baseline.

Silver was detected above MV-18 baseline (0.4 mg/kg) in nine samples and ranged from 2.4 mg/kg at the 1-foot depth in SB08-02 to 5.0 mg/kg at the 3-foot depth in SB08-11. The level of silver is within the USGS and NAS maximum of 5 mg/kg.

Selenium was detected above the USGS baseline of 0.5 mg/kg and at the 3-foot depth in SB08-03 at 0.74 mg/kg.

Vanadium was detected above NAS baseline (78.2 mg/kg) in five samples and ranged from 79.7 mg/kg to 103 mg/kg. The level is below the USGS baseline of 500 mg/kg and is not considered excessive.

Zinc was detected above the NAS baseline (104.1 mg/kg) in two samples taken at the 1- and 3-foot depth in SB08-01. The concentrations were 8,710 mg/kg and 4,120 mg/kg, respectively. SB08-01 also contained the high levels of copper and the cause of the high concentrations of zinc may also be from sample extraction.

Analysis of soil samples shows that organic contamination is localized and shallow. Inorganic analysis showed most elements at levels typical of the station, though a localized area away from the former tank and sump may have elevated levels of lead and zinc, or possibly brass particles.

Ground Water

A total of five wells were sampled and analyzed for BNAs, VOCs, PCBs, TPHC, metals, and nonmetals. These wells were sampled six times in four quarters and include:

- W08-02(A2)
- W08-03(C)
- W08-04(A1)
- W08-05(A2)
- W08-06(A2).

Previously installed wells W08-01(A2) and MEW-82(B2) were sampled four times over the year. Samples from these wells were analyzed for VOCs and ions.

A statistical analysis of detected chemicals in water is provided in Tables 11.4-4 and 11.4-5.

Common laboratory contaminants acetone and methylene chloride were found in many samples and in most cases, each detection was associated with method blank contamination. Methylene chloride was detected in the analysis of six wells.

A aquifer wells contained elevated levels of VOCs. The following is a summary of these organics:

<u>Compound</u>	<u>Range (µg/l)</u>		
	<u>W08-01(A2)</u>	<u>W08-05(A2)</u>	<u>W08-06(A2)</u>
1,1,1-Trichloroethane	6 to 18	22 to 37	44 to 70
1,1-Dichloroethylene	7	23 to 43	9 to 19
1,1-Dichloroethane		10 to 14	8 to 12
Trichloroethene	6 to 10	5 to 6	

Trichloroethene was found at 11 µg/l in one sample from B2 aquifer well [MEW-82(B2)].

Well W08-04(A1) also contained trichloroethene which ranged from 5 µg/l to 6 µg/l.

These VOCs may be from the sump at Site 8 or from upgradient sources such as Site 9 or the MEW Area. Continued work is planned to delineate the various potential sources of organic contamination at NAS Moffett Field.

Several metals and nonmetals were consistently above the quantitation limit. These elements and compounds are presented in Tables 11.4-4 and 11.4-5.

Naturally occurring inorganic constituents in the soils (aluminum, calcium, sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has contributed to the natural degradation of the water quality. Therefore, the naturally occurring elements and compounds will not be discussed in this text.

Metals found in the ground water include antimony, arsenic, manganese,

selenium, iron, and zinc.

Manganese was found in 23 samples which ranged from 15.3 µg/l to 207 µg/l. The concentration varied with well depth and ranged from 73 µg/l to 100 µg/l in the C aquifer to 15 µg/l to 207 µg/l in the A aquifer. Iron was found in all wells. The concentrations varied with well depth and ranged from 101 µg/l to 131 µg/l in W08-03(C), 125 µg/l to 577 µg/l in W08-06(A2), and 425 µg/l to 1,830 µg/l in W08-04(A1). These concentrations of manganese and iron are typical of the station ground water.

Selenium was found in one sample from W08-06(A2) at 12 µg/l. Zinc was found in only one sample each from two wells at concentrations of 71.1 µg/l and 91.2 µg/l. These inconsistent detections are not indicative of ground water contamination.

Arsenic was found in W08-03(C) ranging from 11.8 µg/l to 14.6 µg/l. Though it was found at only one location, it was found in more than one sample. It appears to be consistent within one well but at a very low level, which would indicate limited areal extent. Additionally, it was not found in A aquifer wells.

Antimony was found above quantitation limits in three samples from W08-04(A1), in the first two quarters of monitoring, though a duplicate of one sample showed a sub-quantitation limit concentration. Four other samples and duplicates from this well in the last two quarters of sampling showed non detected or sub-quantitation limit concentrations (one sample). Concentrations ranged from 65.6 to 134 µg/l. Antimony was found at low levels in only one other A well sample and in one C well sample. These data indicate that the actual presence of antimony at significant levels is suspect.

In summary, only arsenic and common saltwater and ground water elements were found consistently in Site 8 wells. The occurrence of arsenic in the C aquifer, but not in the A aquifers does not indicate a local source of arsenic.

12.0 OLD FUEL FARM - SITE 9

12.1 DESCRIPTION AND HISTORY

The Old Fuel Farm is located near Building 12 in the block formed by Bushnell Road, Severyns Avenue, North Akron Road, and McCord Avenue, and is southwest of the runways (Figure 12.1-1). Site 9 also includes The Old NEX Gas Station which was at the site of Building 31. The site was used for storage of fuel from the 1940s until 1964. Aviation gas (AVGAS) was stored in six underground 10,000-gallon steel tanks in an unpaved area that is now the parking lot of Building 12 (NEESA, 1984). ERM West (1986b) was able to locate five tanks in this area (Tanks 47, 48, 49, 50, and 56). Motor vehicle gas (MOGAS) was stored in two underground 5,000-gallon steel tanks near Building 31 (NEESA, 1984). Spillage occurred when filling the tanks or sampling fuel. In the mid-1960s two of the AVGAS tanks (numbers unknown) began leaking and were never repaired. In 1964, the fuel farm was abandoned and the tanks were filled with water.

Since completion of the Phase I investigation, Site 9 is considered to include the area bounded by Bushnell Road to the north, Wescott Road to the south, McCord Avenue to the west, and Hangar 1 to the east. New areas of potential sources were identified in the Phase I investigation by a soil-gas survey. To simplify the referencing for this and future work, these areas were given subarea designations. The Old Fuel Farm area is now designated area 9A and the Old NEX Gas Station is referred to as area 9B. Other potential source areas identified in Phase I are designated areas 9C through 9G. The locations of these areas are shown in Figure 12.1-1.

In general, the Site 9 area is flat with a slight upward slope from the north to the south. The north end has an elevation of approximately 15 feet msl, and the south end has an approximate elevation of 23 feet msl. The area is covered by buildings and asphalt or concrete paving except for minimal landscape shrubs and trees around the buildings. Building and parking area locations are shown in Figure 12.1-1. Runoff in the area is channeled via street gutters to storm drains.

In addition to the abandoned fuel tanks, a number of other tanks and sumps at/or upgradient of Site 9 were identified in the underground tank survey. These tanks included: two paint waste sumps (Sumps 61 and 62) that drain to the sanitary sewer at Site 17; two removed tanks (Tanks 19 and 20); nine gasoline tanks (Tanks 33 through 41) at an auto service center; two standby diesel fuel tanks (Tanks 14 and 32) for generators; two abandoned tanks (Tanks 67 and 68) believed to contain petroleum hydrocarbons at Site 14; Sump 66 believed to contain dry cleaning solvents at Site 18; two abandoned tanks (Tanks 51 and 52) one of which is believed to have contained kerosene; an abandoned fuel oil tank (Tank 1); an oil/water separator (Sump 25) at Site 15; and a vapor condensation recovery tank (Tank 42) also at Site 15.

At the upgradient edge and near the southwest corner of Site 9 are three abandoned deep water wells. These wells intersect several aquifers. The wells are believed to be approximately 1,000 feet deep.

12.2 FIELD INVESTIGATION

The field activities for Site 9 include:

- Borehole geophysical logging and coring
- Installation of monitoring wells
- Ground water and soil sample chemical analysis
- Soil gas survey
- Water level measurement.

12.2.1 Geophysical Borings

Six geophysical borings were drilled at Site 9. All of the borings penetrated the geologic unit which contains the C aquifer and bottomed at approximately 250 feet bls. The total depths of the six borings, GB-7 through GB-12, are shown in Table 2.3-2 and the locations are shown on Figure 12.2-1. Geophysical methods used tools included resistivity, spontaneous potential, and natural gamma. A caliper tool was used to measure borehole diameter. The borings were continuously cored for lithologic description and correlation with the E-logs. Because of the unconsolidated nature of some of the subsurface materials, 100 percent core recovery was not accomplished. Upon

completion of the logging, the borings were abandoned by backfilling with a bentonite cement grout. Boring and geophysical logs are presented in Appendices I and J, respectively, in the December 1988 Quarterly Report (IT, 1988e).

12.2.2 Ground Water Monitoring Wells

Nine ground water monitoring wells were installed in the Phase I investigation. These included five A-aquifer wells, three B-aquifer wells, and one C-aquifer well. The locations of these wells are shown in Figure 12.2-1. Borehole and well construction details from each well are shown in Table 2.3-2. Boring logs are presented in Appendix I of the December 1988 Quarterly Report (IT, 1988e). The A-aquifer wells were screened to depths ranging from 13.3 to about 55 feet bls, the B-aquifer wells from about 60 to 117 feet bls, and the C-aquifer well from 157 to 167 feet bls. Monitoring well designations completed in the A, B, and C aquifers are as follows:

- A aquifer wells - W09-06(A1), W09-07(A1), W09-13-(A2), W09-14(A2), and W09-27(A2)
- B aquifer wells - W09-04(B2), W09-05(B3), and W09-15(B2)
- C aquifer well - W09-3(C).

Wells W09-03(C) and W09-05(B3) were installed downgradient of the Old Fuel Farm Tanks (47 through 50) to monitor the possible vertical or lateral migration of contaminant leaks. Wells W09-07(A1) and W09-13(A2) were installed upgradient from the Old NEX Gas Station. Wells W09-14(A2) and W09-15(B2) were installed downgradient from Sump 66 (Site 18) and Tanks 67 and 68 at Site 14. W09-03(C) was installed upgradient of areas 9A and 9B to evaluate deep aquifer contamination from upgradient sources.

12.2.3 Soil Gas Survey

A soil gas survey was conducted to screen for possible contaminants from fuel tanks, sumps, ditches, and spills. Twenty-one transect lines, with sample points approximately every 50 feet along each line, were set-up primarily in north-south trends. Several shorter transect lines, TL-31, TL-32, TL-34, and TL-36 were not on the north south trends because of building interference. Soil-gas samples were collected from the shallow soil and/or vadose zone from

approximately 5 feet bls. The soil gas survey is discussed in Section 12.4. The soil gas sample location map and sample results are included as figures and tables for that section.

12.2.4 Soil Samples

Soil samples were collected for chemical analysis from all monitoring well borings at depths of 1-, 3-, and 5-foot depths. These samples were analyzed for pH, metals to nonmetals, PCBs, VOCs, and BNAs. The analytical results are discussed in Section 12.4.

12.2.5 Ground Water Samples

Ground water samples were analyzed for VOCs, metals to nonmetals, PCBs, major ions, TDS, BNAs, pH, specific conductivity, and TPHC. Analytical results are discussed in Section 12.4.

12.2.6 Water Level Measurements

Water level measurements were taken quarterly from all Phase I wells and from selected existing ESA wells. ESA wells included W09-01(A1) and W09-02(A1). Water level data from these wells were used to construct potentiometric surface maps of the A aquifer (Appendix B of this report). Monthly water level measurements were taken from November 1988 through October 1989 from all study wells. Data from these measurements have been compiled into hydrographs illustrated in Appendix A.

12.3 HYDROGEOLOGY

12.3.1 Site Geology

The stratigraphic section at Site 9 consists of sands overlain by a thick clay, followed by a sequence of sediments that become finer in the upper part of the section. The thick, blocky sand above the clay grade into thin interbedded sand and clay near the surface. The thicker, blocky sand appear to be laterally continuous over the site, while the thin interbedded sand is discontinuous. Several clay layers appear to be continuous and are used to divide the section into units that delineate the aquifers (Section 12.3.2). These units and their lateral distribution are shown in interpretive cross sections (Figures 3.3-2, 3.3-3, and 3.3-5) and in a conceptual fence diagram

(Figure 12.3-1).

The lowermost unit investigated consists predominantly of thick sand with interbedded clay. This unit corresponds to the C aquifer of previous studies and to Iwamura's (1980) lower confined aquifer. The top of the sand is approximately 155 feet below grade at Site 9 and about 100 feet of the unit was penetrated in deep borings. The sand is fine to coarse with gravel and shells. Poor recovery in cores from this zone limit the descriptions of the sand. Interbedded silt and clay are medium brown to dark gray and vary from soft to stiff, and from medium to low plasticity.

Previous work and nearby site studies identified a thick clay overlying the C aquifer which is about 50 feet thick and is regionally extensive. This clay unit corresponds to the B/C Aquitard. Within this thick clay is a regionally extensive sand unit from about 165 to 175 feet bls in the Site 9 area. This unit has been included in C aquifer. The clay above the upper sand of the C aquifer, is the B/C aquitard. The top of the B/C clay is from 120 to 130 feet bls. The clay is predominantly dark gray with medium gray and brown patches which are commonly silty. The clay is moderate to high in plasticity and is stiff. It also contains thin lenses of fine sand.

Above the B/C clay is a unit of thick sand which is approximately 25 feet thick. The unit extends from approximately 95 to 130 feet bls and corresponds to the B3 subaquifer. Geophysical logs indicate that the B3 subaquifer is composed of one or two thick sand beds and the beds have gradational bases and tops. Boring logs show predominantly clay, though low core recovery suggests the presence of sand. Electric logs show that the sand is laterally continuous. The B3 subaquifer sand is black to gray and fine to coarse, with pebbles, gravel, and clay.

The clay above the B3 subaquifer is a brown to gray and is approximately 4 to 6 feet thick. The top of the clay occurs at about 95 to 105 feet bls. The clay corresponds to the B2/B3 aquitard and consists of a stiff clay with low to moderate plasticity.

The sand unit above the B2/B3 clay ranges from 20 to 30 feet thick and extends

from about 70 to 105 feet bls. The B2 subaquifer is composed of thick and thin interbeds of sand and clay. Electric log characteristics indicate a mix of both gradational and flat based sand. The sands are black to gray, medium to coarse grained, and vary from gravelly, clayey, to silty.

The clay above the B2 subaquifer is approximately 4 to 8 feet thick and the top occurs at about 70 feet bls. The unit corresponds with the A2/B2 aquitard. The clay is brown to gray, stiff, and medium to high plasticity.

Above the A2/B2 aquitard is a 45- to 50-foot-thick unit of interbedded sand and clay. Electric log characteristics show some of the sand occurring in lenses, becoming finer in texture, upward in the section, and becoming thicker and coarser at the base of this section. The A2 subaquifer is a sand that is approximately 30 to 75 feet bls. The sand is medium to coarse grained, and dark gray to black or tan. The A2 subaquifer contains variable amounts of clay, silt, and gravel.

Above the A2 subaquifer is a clay which is 5 to 14 feet thick. The clay corresponds to the A1/A2 aquitard and has a top which occurs approximately 25 feet bls. Electric logs indicate that the clay is laterally continuous. The clay is light to dark gray with some brown mottling in places. It is soft to stiff, moderately plastic, and silty and sandy.

The uppermost unit is comprised of interbedded gravel, sand, and silty clay. Gravel layers are usually clayey, sandy, and silty, while the sand is poorly to well sorted. The sand and gravel ranges from black or dark gray to tan or white. The clay is gray, soft to stiff, moderate to highly plastic, and is silty or sandy. Electric log characteristics indicate that the sand is not laterally continuous. The A1 subaquifer occurs from about 25 feet bls to the surface fill or topsoil.

12.3.2 Hydrology

Surface Water

Site 9 is mostly covered by asphalt paving and structures. Runoff of surface water flow is diverted to local catch basins and then into the storm drainage

system.

Vadose Zone

The saturated zone at Site 9 is approximately 15 to 22 feet bls. The zone is generally composed of sandy, silty clay and silt. Sediments are unsaturated to a depth of 12 to 18 feet. The moisture profile of the unsaturated zone and its physical characteristics have not been investigated.

Ground Water

The aquifers at Site 9 are composed of sand and gravel deposits with varying amounts of silt and clay. The subaquifers are the A1, A2, B2, B3, and C. The approximate thickness and depth range of each subsurface unit is summarized in Table 3.4-1.

Data obtained from aquifer tests in the A aquifer at other sites on Moffett indicate that the hydraulic conductivity ranges from 10^{-3} to 10^{-5} cm/sec. These values are typical of silty sand to silt.

The A aquifer is comprised of discontinuous silty sand and gravel and interbedded silty clay. Drilling and monitoring well data indicate that the aquifer responds as a confined aquifer. Ground water was generally encountered at 15 to 22 feet bls and then stabilized at 8 to 9 feet bls. Appendix B shows the potentiometric surface maps for Site 9 for March 1989, June 1989, and September 1989. The potentiometric surface is from approximately 8 to 15 feet above msl over the site and has a gradient of 0.005. The phreatic surface slopes to the north-northeast towards the bay. This gradient does not vary significantly in direction or slope throughout the seasons.

Hydrographs of the A aquifer wells (Appendix A) indicate an annual change in head (September 1988 to September 1989) of about 0.5 foot. Anomalous data points occur on the hydrographs from well W09-07(A2) in January and April, and for well W09-02(A1) in August. The wells are within 70 lineal feet of each other and anomalous data points show variations between the wells of 0.65 to 1.0 feet. Similarly, the hydrograph of well W09-13(A2) shows anomalous water level elevations for January. Insufficient information is available to explain these anomalies.

The B aquifers are comprised of thick and thin beds of sand with varying amounts of interbedded gravel, silt, and clay. Potentiometric surface maps for the B aquifers have not been generated because of limited data. Heads in the B Aquifer range from 7 to 15 feet above msl.

Hydrographs for B2 and B3 aquifer wells show an annual variation of about 0.4 feet [W09-04(B2) and W09-05(B3)]. Anomalous water level elevations in well W09-15(B2) for May is postulated to be a field measurement error or recording error.

Several factors indicate that the A1 and A2 subaquifers are interconnected upgradient of Site 9. The changes in head in the A2 subaquifer and A1 subaquifer are similar and they do not appear to interconnect with the B2 or B3 subaquifers. The rise in water levels from October to January in A1 and A2 subaquifer wells is about 0.5 feet and is more gradual than in the B2 and B3 aquifer wells for the same period (0.7 to 1.2 feet).

Water level data from well W09-03(C) show the potentiometric surface at about 15 feet above msl. The hydrograph (Appendix A) for this well shows a change in head from September 1988 to September 1989 of about 1.1 feet. Data from wells W09-14(A2), W09-15(B2), and W09-03(C) indicate that the C aquifer has a higher head than the A and B aquifers. A regional potentiometric surface map of the C aquifer is presented in the MEW RI (HLA, 1987b). This map shows the flow in the C aquifer to be towards the north northeast.

12.4 NATURE AND EXTENT OF CONTAMINATION

12.4.1 Sources

There are several suspected local sources of contaminants at or near Site 9. They include:

- Old Fuel Farm - Six tanks
- Old NEX Gas Station - Two tanks.

In addition to these abandoned fuel tanks, a number of other tanks and sumps

that are upgradient or within Site 9 are suspected sources and include:

- Two paint waste sumps (Site 17)
- Nine gasoline tanks (NEX Station)
- Two standby diesel fuel tanks (Tanks 14 and 32, Site 10)
- Four abandoned tanks (Tanks 67 and 68, Site 14; and Tanks 51 and 52, Site 10)
- Dry cleaning sump (Site 18)
- An oil/water separator (Sump 25, Site 15)
- Vapor condensation recovery tank (Tank 42, Site 15).

These suspected sources will be discussed separately under the appropriate site locations. The Old Fuel Farm and Old NEX Gas Station will be discussed in detail since they are potential sources of contamination resulting from leaks and/or spills.

A source of regional ground water contamination exists upgradient (MEW Site) and a plume from that source has been mapped to extend under Site 9 (HLA 1987). Regional ground water contamination from this source is suspected to exist in the A aquifer at NAS Moffett Field.

Other potential sources within Site 9 are subsurface horizontal conduits, (i.e., sewer and storm drainage systems which traverse the site). A study by Barrett, Harris and Associates (1985) indicated that the sanitary sewer system at NAS Moffett Field dated back to the 1930s and was predominantly made of vitrified clay pipes ranging from 6 to 18 inches in diameter. The sewer system's contents flow from the buildings and facilities by gravity and conveys the sewage to a pump station at the north end of Marriage Road. From there it is pumped to the Sunnyvale system. The storm drain system includes catch basins, field inlets, and drainage manholes. The storm system either drains to a marsh area north of the base or is diverted to the drainage system on the east side of the station. From the marsh, which acts as a holding area, storm water is pumped to Stevens Creek. On the east side of the station, the storm waters are drained to Pump Station 191 and into an off-site canal that leads to Guadalupe Slough.

12.4.2 Review of Chemical Analyses

Surface Water

The Site 9 area is predominantly covered with asphalt and concrete paving, with culverts draining runoff to storm drains. Other than possible occasional ponding of rain water, no surface water bodies are present at Site 9.

Soils

A total of 30 soil samples were collected from 9 borings at depths of from 1 to 8 feet bls. A statistical analysis of analyte concentrations detected above quantitation limits is presented in Tables 12.4-1 through 12.4-4.

Bis(2-ethylhexyl)phthalate was found at the 5-foot depth in one well boring (400 ug/kg).

Nine volatile organic compounds were detected in soil samples. 1,1,2,2-tetrachloroethane (PCA) was detected in six samples at concentrations ranging from 220 to 420 ug/kg. Three of these samples were from wells W09-07(A1) and W09-27(A2), which are in areas 9B and 9C (see Figure 12.2-1). The presence of this compound in all three samples from each of these wells indicates a potential source in these areas. However, all of the reported detections in the W09-07(A1) samples were associated with blank contamination. Actual concentrations were estimated to be below the quantitation limits. Phase II sampling in these areas may clarify the unusual occurrence of this compound.

1,2-Dichloroethene was detected in one sample above the quantitation limit (5 ug/kg). PCA was detected at the 3-foot depth at 6 ug/kg in boring W09-14(A2). Trichloroethene (TCE) was detected in five soil samples above the quantitation limit. The range of concentrations was from 5 to 43 ug/kg. TCE was detected in well borings W09-14(A2), W09-03(C), and W09-15(B2). The concentrations and distribution are shown in Plate E-7 (Appendix E of this report). These three wells are located in close proximity which may indicate a possible local source of contamination.

Acetone and methylene chloride were detected in all soil samples from Site 9. The occurrences were low level and, with three exceptions, were associated

with method blank contamination. The three samples from W09-15(B2) had acetone and methylene chloride at concentrations of 10 to 41 µg/kg and 10 to 26 µg/kg without blank contamination reported. These concentrations are similar to other samples collected at the site that ranged from 13 to 140 µg/kg for acetone and 8 to 130 µg/kg for methylene chloride. 2-butanone was found in one sample from W09-04(B2) at 23 µg/kg, which was associated with blank contamination. W09-27(A2) contained 2-butanone in one sample at 20 µg/kg.

Carbon disulfide was detected at 7 ug/kg in the 1-foot depth in W09-05(B3).

Three petroleum hydrocarbons (ethyl benzene, toluene, and total xylenes) were found above quantitation limits in site soils at various locations. Ethyl benzene was detected at 9 ug/kg in the 1-foot depth from W09-13(A2). Toluene was detected at 37 ug/kg in the 1-foot depth from W09-05(B3). Total xylenes were detected at the 1-foot depth from W09-04(B2) at 5 ug/kg and at the 1-foot depth from W09-13(A2) at 24 ug/kg.

With the exception of TCE in soil samples from well borings near the dry cleaners (Site 18), the occurrence of fuel and solvents in soil samples is insufficient to indicate specific source areas. Additional data collected in Phase II may provide the information necessary to identify specific sources.

Metals and Ions

Levels of metals and ions were compared to baseline levels established in the NAS Moffett Field area as discussed in Section 3.5. As previously discussed, several elements of common rock forming minerals are naturally present in soils at variable levels. These elements include:

- Aluminum
- Barium
- Calcium
- Iron
- Magnesium
- Manganese
- Potassium
- Sodium.

The elements listed above were found in concentrations that ranged from either

below or slightly above the NAS baselines with some exceptions. Barium was found in three samples from well W09-14(A2) at concentrations ranging from 478 mg/kg to 795 mg/kg, two to four times the NAS baseline of 220.4 mg/kg. However, the level is below the USGS baseline of 5,000 mg/kg. Calcium occurred at levels slightly more than twice the NAS baseline in four samples from W09-14(A2), W09-15(B2), and W09-07(A2). High variability in calcium can be expected at this site due to the proximity to the bay and to the paleodepositional environment. Manganese was found in one sample from W09-14(A2) at nearly five times the NAS baseline of 721 mg/kg from the 3-foot depth. The 5-foot depth had a manganese concentration 1,410 mg/kg, or about twice the NAS baseline, and the 1-foot depth, with a concentration of 241 mg/kg, was well-below baseline. Concentrations of other metals are considered representative of natural variation in soils. A discussion of the other metals and nonmetals that were found at levels above the baselines shown in Table 3.2-1 follows.

Arsenic was detected above the Hetch-Hetchy baseline concentration of 6.3 mg/kg in one sample from W09-27(A2) that had 8.2 mg/kg at the 3-foot depth. This concentration is below the NAS baseline of 8.8 mg/kg.

Beryllium was detected above the Hetch-Hetchy baseline (0.8 mg/kg) in one sample from W09-14(A2) that had 1.2 mg/kg at the 1-foot depth. This concentration is below the NAS baseline of 3.7 mg/kg.

Cadmium was detected above the MV-18 baseline (3 mg/kg) in W09-15(B2) that had 9.4 mg/kg at the 1-foot depth. This concentration is below the USGS baseline.

Chromium was detected at levels slightly above the Hetch-Hetchy baseline of 60 mg/kg in nine samples. Only two samples were above the NAS baseline of 76.5 mg/kg: the 1-foot depths from W09-04(B2) and W09-05(B3) had concentrations of 80.4 mg/kg and 87.1 mg/kg, respectively. These slight elevations above the average NAS baseline are considered natural.

Cobalt was found in one sample above the NAS baseline of 18.6 mg/kg. The 1-foot depth sample from W09-05(B3) had a concentration of 23.5 mg/kg, only slightly above the NAS baseline, but not above the USGS baseline.

Copper was detected in six samples above the MV-18 baseline of 44 mg/kg. The levels detected were only slightly above the baseline with the exception of one sample which had a concentration of 287 mg/kg. This sample was from the 5-foot depth of well W09-15(B2). The 1- and 3-foot depths from this boring had typical concentrations of 26.8 mg/kg and 31.8 mg/kg. Only the sample from W09-15(B2) and W09-07(A1) were above the NAS baseline of 56.7 mg/kg. The W09-07(A1) sample was only slightly above, with a concentration of 57.4 mg/kg.

Lead was detected above the NAS baseline concentration of 28.3 mg/kg in the 1-foot and 3-foot depths in W09-05(B3). The sample collected from the 1-foot depth was 60.2 mg/kg, and the 3-foot sample was 48.0 mg/kg. These levels are only slightly greater than the Hetch-Hetchy and MV-18 baselines of 48 mg/kg and 54 mg/kg, respectively, and much lower than the USGS baseline of 700 mg/kg.

Mercury was detected above the Hetch-Hetchy baseline of 0.1 mg/kg in 22 samples from Site 9. However, none were above the NAS baseline of 0.5 mg/kg. The Hetch-Hetchy baseline is considerably lower than the other baselines and appears to represent that end of the soil composition in which no mercury is present, rather than a typical value where mercury is found.

Nickel was detected above the Hetch-Hetchy baseline concentration of 47 mg/kg in 26 samples. The general trend was a decreasing concentration with depth. The range varied from a low at the 5-foot depth in W09-07(A1) of 48.8 mg/kg to a high at the 3-foot depth of 91.1 mg/kg in W09-14(A2). This latter sample was the only sample that was above the NAS baseline of 88.5 mg/kg, and it was only slightly above.

Silver was detected above the MV-18 baseline concentration of 0.4 mg/kg in nine samples. The range varied from 2.2 mg/kg to 4.7 mg/kg. The highest concentration of 4.7 mg/kg was found in the 1-foot sample from well boring W09-05(B3). All concentrations were below the NAS baseline of 5 mg/kg.

Vanadium was found in only one sample above the NAS baseline of 78.2 mg/kg. The 1-foot sample from W09-05(B3) had a concentration of 106 mg/kg.

Zinc was found in three samples above the NAS baseline of 104.1 mg/kg. The samples were from various depths in three well borings and had a concentration range of 109 to 160 mg/kg, slightly to moderately above the NAS baseline.

The levels of metal to nonmetal elements in soils at Site 9 are considered to be within the variation of natural occurrences. Though the one 5-foot sample from well boring W09-15(B2) had a copper concentration of about five times the station baseline, this is an isolated occurrence and does not appear to indicate an anthropogenic origin. If additional sampling in this area during the Phase II investigation show substantially elevated levels of copper, further investigation may be necessary.

Soil Gas

Field testing of shallow soil for total ionizable compounds was conducted at 101 sample stations within a grid system (Figure 12.4.1). A contour map of the total soil gas concentrations (total ionizable compounds) is presented as Figure 12.4-2. The map shows elevated soil gas concentrations in four areas having previously known or suspected sources and in four other areas which were not identified as potential sources before the Phase I investigation. The elevated concentrations were 156.3 ppm at the Old Fuel Farm (Area 9A) and the Paint Shop (Site 17), 78.2 ppm at the Old NEX Gas Station (Area 9B), and 216.3 ppm at the Dry Cleaners (Site 18). Because of the proximity of Area 9A and Site 17 relative to the sample station spacing, data gathered from this area cannot be considered specific to one site or the other. The high concentrations at the previously unidentified areas were 140.2 ppm at Area 9C, 22.4 ppm at Area 9D, 87.5 ppm at Area 9E, 32.4 ppm at Area 9F, and 68.6 ppm at Area 9G.

A total of 43 soil gas samples were collected from selected sample stations and analyzed by GC for 10 predetermined compounds. Results of these analyses are shown in Table 12.4-5.

TCE was detected in 37 GC samples at concentrations ranging from 25 ppb to 941,000 ppb, with concentrations greater than 10,000 ppb located in all areas of Site 9, except for Area 9F which had a high of 3,170 ppb. The highest concentration was from the area near the dry cleaners. PCE is a compound

commonly used in dry cleaning. TCE is one of the degradation products of PCE. This concentration is about one order of magnitude greater than all other areas and indicates Site 18 as a possible source of TCE.

1,1-DCE was detected in 20 GC samples at a range of 16 to 56,700 ppb. Concentrations greater than 10,000 ppb occurred at Areas 9B and 9F, Site 18, and between Areas 9D and 9E. Levels greater than 1,000 ppb occurred in samples from Area 9G and on the south side of Site 18.

1,1-DCA was detected in eight GC samples at a range of 1,487 to 230,000 ppb. The eight detections were in samples from Areas 9A - Site 17, 9B, 9F, and on the south side of Site 18.

Cis-DCE was found in 31 GC samples at concentrations ranging from 115 to 97,300 ppb. The compound was found in all of the subareas of Site 9 except for Area 9A - Site 17.

1,1,1-TCA was detected in seven GC samples at levels ranging from 388 to 84,640 ppb. The low (388 ppb) was found at Area 9B. The compound was also found in Areas 9A - Sites 17, 9F, between 9D and 9E, and on the south side of Site 18.

1,1,2-TCA was detected in three GC samples. Two samples collected from Area 9A - Site 17 had concentrations that ranged from 580,000 to 586,000 ppb. A concentration of 3,390 ppb was detected in one sample from Area 9B. The presence of high concentrations in both samples from Area 9A - Site 17 and not in other areas is indicative of a local source of 1,1,2-TCA.

Benzene was detected in nine GC samples which ranged from 17 to 14,300 ppb. Toluene was found in 14 samples at concentrations ranging from 18 to 14,100 ppb. The highest concentrations of these compounds were found in samples from Areas 9A - Site 17 and 9B. Other detections occurred in samples from Area 9C, 9E, 9F, and Site 18. The occurrence of elevated concentrations of fuel compounds benzene and toluene at the former fuel storage areas 9A and 9B suggest these areas as sources.

The compounds m- and p-xylene were detected in two GC samples from Area 9B. Concentrations were 33 and 96 ppb. O-xylene was detected in one GC sample from Area 9B and one from the northern part of Site 9. The concentrations were 26 and 28.5 ppb.

12.4.4 Ground Water

Two wells were installed in the A aquifer by other investigators [W09-01(A1) and W09-02(A1)]. Analyses of three rounds of ground water samples from these wells showed that Site 9 ground water contained a variety of VOCs, including DCA, DCE, TCA, and TCE (ESA, 1986a). The highest concentrations found by ESA were observed at well W09-02(A1), which included 1,1-DCA (71 to 120 µg/l), 1,1-DCE (170 to 340 µg/l), 1,1,1-TCA (180 to 240 µg/l), TCE (4,600 to 11,000 µg/l), cis-1,2-DCE (620 to 1,200 µg/l), and trichlorotrifluoroethane (44 to 250 µg/l). Samples from well W09-01(A1) contained a maximum of 60 µg/l of TCE, 20 µg/l of 1,2-DCA and 14 µg/l of CIS-1,2-DCE, 20 µg/l of 2,2 oxybispropane, and less than 5 µg/l of all other VOCs. Virtually all of the volatiles detected were chlorinated suggesting solvents and degreasers as the source. Petroleum hydrocarbon chemicals were also detected in the ground water.

For the RI a total of 11 A-aquifer monitoring wells were sampled at Site 9 for the one-year monitoring period. Two Phase I and three older wells are in the A1 subaquifer, and three Phase I and three older wells are in the A2 subaquifer. The older wells were installed by MEW and are designated B1 subaquifer wells but are considered to be A2 subaquifer wells in this study (see Section 3.0 for discussion). Phase I well samples were analyzed for the full suite of analytes in the NAS Moffett Field testing program, while samples from older wells were tested only for anions and VOCs.

A total of seven BNA compounds were reported in samples from the wells at Site 9, though only two were detected above quantitation limits.

4-nitrophenol was detected at 60 ug/l in the A aquifer (quantitation level of 50 ug/l), and bis(2-ethylhexyl)phthalate was detected at 27 ug/l in the A aquifer and 44 µg/l in the B aquifer (quantitation level of 10 ug/l). The limited occurrence of these compounds is an indication that ground water

contamination by BNAs has not occurred.

Tables 12.4-6 through 12.4-8 shows the compounds detected above quantitation limits and the number of occurrences, for the A, B, and C aquifers, respectively. Results of statistical analyses of these data are also included in the table. A summary compilation of all compounds detected in ground water samples is presented in Appendix D. Plates showing the distribution of chemicals are continued in Appendix E of this report.

A total of eleven VOCs were detected in Site 9 monitoring wells. Toluene and chloroform were each detected only one time above quantitation limits. 1,2-DCA was detected in W09-06(A1) three times at low levels (5 to 6 ug/l). 1,2-DCA may be present in ground water at well W09-06(A1) but is not a widespread or consistently measurable contaminant at this site. Acetone and methylene chloride were detected with frequency in all wells; however, nearly all detections were reported with associated method blank contamination. High concentrations of acetone (up to 3,200 ug/l) and methylene chloride (up to 6,800 ug/l) were reported in four of the wells. These wells also had high concentrations of TCE with the maximum values ranging up to 36,000 ug/l. A discussion of sample contamination by common laboratory contaminants is included in Section 2.0.

Four of the remaining compounds were reported consistently in four to seven of the A aquifer wells at Site 9. The compounds are:

- 1,1,1-TCA
- 1,1-DCA
- 1,1-DCE
- 1,2-DCE (total).

1,1,1-TCA and 1,1-DCA were reported in six wells; and 1,1-DCE and 1,2-DCE (total) were detected in eight and seven wells, respectively. Because of the relatively high concentrations of TCE in samples, most of the reported concentrations of these compounds were estimated below sample quantitation limits. The exceptions occurred in MEW 81A(A1) which had 1,1-DCA; 1,1-DCE; and 1,2-DCE (total) at concentrations above quantitation limits, and in MEW 46B1(A2) and MEW 75A(A1) which had 1,2-DCE (total) at levels above the limits. TCE occurred with consistency in eight of the wells and also had the highest

concentrations. TCE was detected at a maximum of 36,000 ug/l in well W09-14(A2), downgradient (north) of the dry cleaners (Site 18). The distribution of VOCs and the range of concentrations detected above quantitation limits for the six rounds of sampling are shown in Plate E-15.

The limited well data are insufficient to determine specific NAS Moffett Field source areas relative to the regional plume. Additional data will be gathered in the Phase II investigation, and during tank removal (Tanks 56A-D) which is scheduled for Fall 1990. Evaluation of Phase II data will determine if sufficient data exist to characterize the site.

Samples from the B and C-aquifer wells show frequent low level detections of acetone and methylene chloride, mostly associated with method blank contamination. Other organic compounds found were one or two-time detections in a single well, and/or were below quantitation limits. These data do not indicate that organic contamination is present in the B or C-aquifers.

Samples from Phase I and previously installed wells were also tested for major ions and all Phase I well samples were analyzed for metals. Major ion analysis was limited to the first four rounds of sampling (two quarters) for all wells.

Six metals which are common constituents of sea water or local ground water were detected consistently in all five Phase I A-aquifer wells. These metals and their concentration ranges are as follows:

- Calcium 76,300 to 160,000 µg/l
- Iron 106 to 2,240 µg/l
- Magnesium 31,800 to 90,000 µg/l
- Manganese 16.2 to 762 µg/l
- Potassium 5,110 to 15,400 µg/l
- Sodium 31,300 to 77,000 µg/l.

Though the Site 9 area is not as severely intruded by bay water as the northernmost sites at the station, the concentrations of calcium, magnesium, potassium, and sodium shown above reflect salt water intrusion. The concentrations of iron and manganese are typical of A aquifer water at the station. Iron

concentrations are within the DWR background ranges (Table 3.5-1) and manganese, though higher, is typical of the station ground water.

The distribution of all metals detected above quantitation limits and the range of concentrations over six rounds of sampling are shown in Plate E-16.

One other metal was detected above quantitation limits consistently (50 percent of the samples or more) in the A aquifer wells. Selenium was detected consistently in W09-07(A1) and W09-13(A2) at a range of 5 to 14.1 $\mu\text{g/l}$. These concentrations are well below the DWR background for the region (Table 3.5-1).

Three other metals were detected above quantitation limits one or two times in several wells. Aluminum was found in three samples from three wells at concentrations ranging from 205 to 458 $\mu\text{g/l}$; antimony occurred three times in two wells ranging from 64.8 to 129 $\mu\text{g/l}$; and vanadium was found one time at 51.1 $\mu\text{g/l}$. These infrequent occurrences are not considered indicative of ground water contamination by these metals.

Four metals were detected above quantitation limits consistently in three B and one C-aquifer wells at Site 9. This includes two B2 wells, one B3 well, and one C well. The metals detected and the range of concentration are as follows:

- Calcium 31,500 to 49,400 $\mu\text{g/l}$
- Magnesium 11,600 to 20,900 $\mu\text{g/l}$
- Manganese 59.8 to 156 $\mu\text{g/l}$
- Sodium 38,700 to 60,900 $\mu\text{g/l}$.

Iron and potassium were also reported consistently in all four wells, but predominantly at levels below quantitation limits. The detected concentrations for these metals above quantitation limits are:

- Iron 100 to 893 $\mu\text{g/l}$
- Potassium 10,400 $\mu\text{g/l}$.

Concentrations of the six metals listed above are considerably lower than those reported for the A aquifer and are more typical of the background ranges reported by the DWR (Table 3.5-1). Only potassium was above the background

levels in one sample. The significant difference between the two aquifers of these common metals supports the contention that the two are separate hydraulic units.

The distribution of metal detections above MDLs and concentration ranges is shown in Plate E-16.

Arsenic was the only other metal detected above quantitation limits consistently in any wells and ranged from 10.6 to 15.3 $\mu\text{g/l}$ for the B aquifer wells. Concentrations of arsenic ranged from 12.0 to 15.3 $\mu\text{g/l}$ in five samples from well W09-04(B2). Arsenic was also found only slightly above the quantitation limit of 10 $\mu\text{g/l}$ in two samples (one a duplicate) from W09-05(B3) at 10.4 $\mu\text{g/l}$ to 10.6 $\mu\text{g/l}$.

Other occurrences of metals above quantitation limits in B aquifer wells were very limited. Aluminum was detected two times in two wells at a concentration range of 321 to 840 $\mu\text{g/l}$. These limited occurrences are not considered indicative of ground water contamination.

Samples from all nine A aquifer wells were analyzed for ions in the first two quarters of sampling. The A wells include three wells designated B1 aquifer wells by MEW. These wells are considered to be in the A2 subaquifer. Four of six ions were detected consistently in all wells. These ions are common in sea water and ground water. The ranges of concentrations for these ions in the nine wells are as follows:

- Bicarbonate 260 to 590 mg/l
- Chloride 29 to 78 mg/l
- Nitrate 0.1 to 7.0 mg/l
- Sulfate 90 to 1,020 mg/l.

Fluoride was detected in one sample from W09-06(A1) at 2.8 mg/l. Total dissolved solids detected for the Site 9A wells ranged from 520 to 1,960 mg/l.

Major ions were tested for in all six of the B and C-aquifer wells. Three ions were detected consistently in all wells and these ions are common in ground water and sea water. The ions and concentration ranges are as follows:

- Bicarbonate 210 to 530 mg/l
- Chloride 2 to 27 mg/l

- Sulfate 13 to 58 mg/l.

Carbonate was detected one time in well W09-05(B3), and fluoride was detected a total of three times in wells W09-04(B2), W09-05(B3), and W09-03(C). Total dissolved solids for all the wells ranged from 200 to 390 mg/l.

Bicarbonate levels in the B and C aquifers are similar to those in the A aquifer. Chloride and sulfate levels are lower in the B and C aquifers, and, while nitrate was consistently detected in the A aquifer, it was not detected in the B and C aquifers. These anion component data also support the idea that the A, B, and C aquifers are separate hydraulic units.

13.0 CHASE PARK AREA AND RUNWAYS - SITE 10

13.1 DESCRIPTION AND HISTORY

Site 10 encompasses the runway, the area southwest of the runway, and the area north of the Bayshore Freeway (Figure 13.1-1). The area southwest of the runway is within the area of the ground water plume originating at the MEW Site.

USTs identified in the Chase Park area include three fuel storage tanks (Tanks 19, 20, and 21), one motor oil storage tank (Tank 57), one sump containing vehicle steam cleaning wastes (Sump 58), and an oil/water separator sump (Sump 60). Tanks 19 and 20 have been removed. Fifteen underground tanks and sumps are present north of Chase Park, west of Cody Road, and south of Westcoat Road. Nine of the tanks (Tanks 33 through 41) contained automotive fuel. The sumps contained fuel vapor condensate (Sump 42), oil and water (Sump 25), and dry cleaning fluids (Sump 66). Four abandoned tanks contained kerosene (Tank 51), petroleum hydrocarbons (Tanks 67 and 68), and unknown materials (Tank 52). Recently, Tank 67 was removed and Tank 68 was found closed in place. Some of these potential sources are to be investigated as separate sites as follows:

- Tanks 19 and 20 - Site 14 (south)
- Tanks 67 and 68 - Site 14 (north)
- Sumps 25, 42, and 58 - Site 15
- Sump 60 - Site 16
- Sump 66 - Site 18.

These sites will be discussed in later sections.

13.2 FIELD INVESTIGATION

The Phase I investigation activities for Site 10 consisted of the following:

- Coring and geophysical logging of borings
- Installation of monitoring wells
- Chemical analyses of ground water and soil samples
- A soil gas survey
- Water level measurement in monitoring wells.

The data gathered from these activities provide baseline information on ground water quality in the upper aquifer. The soil gas survey also provides information on potential leakage from underground tanks.

13.2.1 Geophysical Borings

Two deep borings were cored and geophysically logged for stratigraphic and lithologic information. Both borings, GB-27 and GB-30, penetrated the C Aquifer and bottomed at approximately 250 feet bls. The total depth for each boring is shown in Table 2.3-2 and their locations are shown on Figure 13.1-1. Down-hole geophysical logging was conducted using resistivity, spontaneous potential, and natural gamma ray methods. The borehole diameter was measured using a caliper tool. The borings were continuously cored for lithologic description and correlation with the electric logs. Boring and geophysical logs are presented in Appendices I and J , respectively, of the December 1988 Quarterly Report (IT, 1988e).

13.2.2 Ground Water Monitoring Wells

Two monitoring wells were installed in the Site 10 study area. One A-aquifer well, W10-05(A1), was installed between the runways and Hangar 2. A C aquifer well, W10-06(C), was installed in the southeastern portion of the Site 10 to act as a "background" well for the deep component of the C aquifer. The A aquifer well was screened from 8 to 13 feet bls and the C aquifer well was screened from 166 to 171 feet bls. These wells augmented three existing wells installed by other investigators. Well locations are shown on Figure 13.1-1. Borehole and well construction details for each well are provided in Table 2.3-2.

13.2.3 Soil Gas Survey

Soil-gas sampling was conducted in the southwestern part of the site to screen for possible ground water contamination from fuel tanks at Site 14 (within Site 10). Sample stations were placed about every 50 feet along two east-west trending lines and one northwest-southeast line (Figure 13.2-1). Samples were collected from the shallow soil or vadose zone at approximately 5 feet bls. Select soil gas stations were sampled for chemical analysis by GC. Because the survey is limited to the Site 14 area within Site 10, the results of the

survey are discussed in Section 17.

13.2.4 Soil Samples

Soil samples for chemical analyses were collected from the vadose zone at depths of 1-, 3-, 5-, 6-, 7-, and 9-foot depths from both monitoring well borings. Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. Preliminary analytical data are available in of the March 1989 Quarterly Report (IT, 1989b), and a summary data compilation is presented in Appendix A of this report. An evaluation of the analytical data is presented in Section 13.4.

13.2.5 Ground Water Samples

Six rounds of ground water samples were collected in four quarters from Phase I wells W10-05(A1) and W10-06(C), and four rounds of samples were collected from previously installed wells W10-02(A1), W10-03(B2), and W10-04(A2). Phase I well samples were analyzed for VOCs, PCBs, pH, specific conductivity, major anions, TDS, metals, BNAs, and TPHC. Samples from pre-Phase I wells were analyzed for VOCs and major anions. Preliminary analytical results of ground water samples are available in Appendix B of the Quarterly Reports for March, August, and November 1989 (IT 1989b, IT 1989c, IT 1989d). A summary compilation of significant findings from chemical analyses is discussed in Section 13.4 and data are provided in Appendix D of this report.

13.2.6 Water Level Measurements

Water level measurements were taken from the Site 10 study wells and from existing ESA wells W10-02(A1), W10-03(B2), and W10-04(A2). Measurements were taken monthly from November 1988 to October 1989 from all wells except W10-04(A2) which was measured from March to October 1989. Data from these wells were used to construct quarterly potentiometric surface maps for the A aquifer system on the east and west sides of the station (divided by the runways) and to determine ground water gradients. These maps are presented in Appendix B and data are plotted on hydrographs included in Appendix A of this report.

13.3 HYDROGEOLOGY

13.3.1 Site Geology

Because Site 10 consists of many subsites spread over the southern part of NAS Moffett Field, stratigraphic information can also be gathered from other sites within the Site 10 area. Stratigraphy beneath the west side of the runways is described in Sections 12.3.2 (Site 9) and 17.3.2 (Site 14). On the east side of the runways Site 10 wells provide information on the stratigraphy. The stratigraphy of Site 10 is shown in cross-sections on Figures 3.3-4 and 3.3-5.

East of the runways, the lowest unit penetrated, from 160 to 180 feet, consists of gravels and sands with interbedded clay. The gravel and sand beds are approximately 5 to 10 feet thick. Though core recovery was very low in these porous units, the limited data indicate that sands and gravels are gray and contain shells. The unit contains interbedded clays that are medium to dark brown, stiff to very stiff, moderately plastic to plastic, and are sandy to silty. This unit corresponds to the C aquifer.

A 35- to 40-foot thick clay overlies the sand of the C aquifer. The top of this clay was penetrated at approximately 115 feet below grade and corresponds to the B/C aquitard zone. This unit is comprised of silty sandy clay with occasional sand stringers. It is typically gray to brown, stiff to very stiff, and plastic; but varies from nonplastic to moderately plastic.

Above the thick clay is a sand unit approximately 20 to 30 feet thick (B3 subaquifer) that ranges in depth from 95 to 130 feet bls. Geophysical logs indicate that the unit is comprised of thick blocky sands. Limited boring log data show the silty sands that range from coarse at GB-27 to fine at GB-30.

A silty sandy clay approximately 8 feet thick overlies the sand. This clay corresponds to the B2/B3 aquitard and was encountered approximately 85 to 100 feet bls. It is dark to medium brown, and varies from soft to stiff and from slightly plastic to moderately plastic.

Overlying the clay is a 15- to 20-foot thick sand unit comprised of blocky sands with silty sandy clay interbeds which range from 70 to 95 feet bls.

Clays within the unit are brown to dark brown, soft, and moderately plastic.

Above the B2 sands (from 65 to 80 feet bls), is a silty sandy clay about 6 feet thick (A2/B2 aquitard). The clays are medium brown, medium stiff, and plastic.

An interbedded sand and clay unit lies above the A2/B2 aquitard clay. The unit ranges from 40 to 45 feet thick and is encountered from 25 to 75 feet bls. Previous studies (HLA, 1987b) have correlated this water bearing sand with the B1 aquifer; however, this study identifies it as the A2 subaquifer. The sequence consists of coarse sediments that are thin, stringy, silty sands and gravels interbedded with clay-rich layers which are predominantly brown, stiff, and plastic.

Above the sand is a silty, sandy clay ranging from 6 to 12 feet thick, which is 15 to 30 feet bls. The clay, corresponding to the A1/A2 aquitard, ranges from medium brown to dark gray, soft to very stiff, is nonplastic.

The uppermost unit overlies the clay and is composed of thin sands and gravels (A1 subaquifer) and interbedded clays. Interbedded clays are brown, very stiff, and range from plastic to nonplastic.

A comparison of resistivity logs from GB-27 and GB-30 to resistivity logs from boreholes at Sites 9 and 14 indicate that deposition in the Site 10 area on the east side of the runways is similar to that on the west side. The log character is interpreted as representing deposition in a transgressive bay-lands environment, followed by regression and a prograding estuarine to fluvial environment. The logs of GB-30 indicate that the deep sand unit is comprised of more clay at this location than at Sites 9 and 14 and may represent deposition away from tidal channels.

13.3.2 Hydrology

Surface Water

Site 10 is largely covered by asphalt paving including roads, parking lots, runways, and other structures. The area surrounding the south end of the

runways is used for agriculture. The area between landing strips is unpaved and covered by natural grasses. Runoff of surface water flow in the paved areas is diverted to a local drainage field and catch basin storm system. Runoff patterns in the agricultural areas have not been determined in this first phase of investigation.

Vadose Zone

Water was first encountered at 9 feet bls in well W10-06(C) in a silty sand. In Site 14 wells, which are within Site 10, ground water was first encountered 13 to 15 feet bls in silt, silty sand, or gravel beds. The vadose zone is predominantly comprised of sandy silty clay in the Site 10 area.

Ground Water

The aquifers at Site 10 are comprised of sand and gravel deposits with varying amounts of silt and clay. Aquifer material on the west side of the runway is described in the hydrogeology of Site 9 (Section 12.3). Aquifer material on the east side of the runway is comprised of silty clayey sand and gravel deposits with clay interbeds. The three aquifers of interest to this study are present throughout the Site 10 area. The specific stratigraphic and lithologic character of each aquifer is also discussed in Section 12.3.2 and below.

No specific data on hydraulic conductivity are available for Site 10 aquifers, as tests were not conducted in the Phase I investigation. Typical hydraulic conductivity values for silty sands range from 10^{-1} to 10^{-5} cm/sec, and from 10^{-1} to 10^{-7} cm/sec for clayey to sandy gravels (interpreted from Freeze and Cherry, 1979).

The A aquifer in the Site 10 area is comprised of sandy gravel and thin sands and gravels with clay interbedded. During drilling of monitoring well W10-06(C) in the southeastern area of Site 10, ground water was first encountered 9 feet bls in a silty sand. On the west side of the runways, in Site 14 wells, ground water was first encountered at 13 to 15 feet bls and rose to about 10 feet bls. In this area, the A aquifer responds as a confined aquifer.

Potentiometric surface maps of the A aquifers show that ground water flow is northerly at a gradient of about 0.004 (September 1989, Plates 8 and 9, Appendix B). Potentiometric maps constructed from three calendar quarters of water level data (Plates 1 through 9), do not show a significant change in gradient steepness or direction with seasonal changes. The potentiometric surface ranges from 4 to 23 feet above msl over the site. Water level data also show a decline in head of approximately 0.5 feet east of the runways, and from 0.9 to 0.7 feet west of the runways for the year from September 1988 to September 1989. This decline may be a result of continuing drought conditions. The hydrographs of Sites 10 and 14 wells are included in Appendix A.

The B aquifers are comprised of thick silty sands. Aquifer material of the individual units in the eastern portion of Site 10 is described in this Section (13.3.2), and for the western portion, in Site 9 hydrogeology (Section 12.3.2). Because of the limited well data the B aquifers have not been mapped. Water level data are presented in hydrographs included in Appendix C. From hydrographs, the potentiometric surface ranges from about 9.5 to 12 feet msl over the eastern Site 10 area.

These data show an annual drop in head of about 0.5 feet in the B2 subaquifer on the east side of the runways, and about 0.7 feet on the west side from September 1988 to September 1989. Again, this is probably a reflection of drought conditions.

The C aquifer is comprised of thick, silty, clayey sands and gravels with clay interbeds over most of the Site 10 area. In the southeastern part of Site 10 (GB-30), sands are thinner and the unit contains more clay overall. The unit is described in more detail in Section 12.3.2. Data from the C aquifer show a rise in head over the same year period of about 0.4 feet.

13.4 NATURE AND EXTENT OF CONTAMINATION

13.4.1 Sources

Historical activities at the runway and Chase Park areas have resulted in potential sources of contamination to soils and ground water at Site 10.

Runoff of precipitation from the runways transports spilled fuels and lubricants to various ditches and drains, which potentially allow contaminants to reach the soil and ground water. Additionally, underground tanks are potential sources of contamination. In the Chase Park area there are three fuel storage tanks, one motor oil storage tank, one sump containing vehicle steam cleaning waste, and one oil/water separator tank. North of the Chase Park area there are 14 underground tanks and sumps, and one removed tank and a tank closed in place. There are also two former tank locations at Site 14 within the Site 10 Chase Park area. Contamination resulting from underground tanks will be discussed in Section 22, Site 19, and contamination from tanks and sumps which are associated with other sites (see Section 13.1) will be discussed in those site-specific sections. The following discussion will focus on the runway area where monitoring well data have been collected.

During the verification step, ESA (1986a) installed three wells [W10-02(A1), W10-03(B2), and W10-04(A2)] between Hangar 2 and the east runway to determine whether contaminants from sources in the area of Hangars 2 and 3 were migrating westerly towards the MEW wells along the west side of the runways. Soil samples taken from borings were not analyzed for chemical contaminants. Results of ground water analyses indicated the presence of very low levels of VOCs in both the A and B aquifers. The dominant VOCs reported were not detected in well W10-02(A1), but a concentration of 20 µg/l was reported for pentanone. Chloroform was detected in well W10-03(B2) at concentrations of 1.7 to 3.8 µg/l. Chloroform levels in the A aquifer wells ranged from 0.1 µg/l to 6.7 µg/l.

Environmental media which may be impacted at this site include shallow and subsurface soils and ground water. Surface water features are not present at this site.

13.4.2 Review of Chemical Analyses

The following discussion presents a review of chemical data obtained from the Phase I activities. An overview of chemical behavior and persistence in the environment is given in Section 23.0. The significance of these results with respect to adverse impacts to the public health and the environment is discussed in Section 24.0. A summary compilation of soil and water analytical

data is included in Appendices C and D of this report, respectively.

Soils

A total of seven soil samples were collected from two well borings at Site 10 [W10-05 (A1) and W10-06(C)]. Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC (Tables 13.4-1 to 13.4-4).

Analysis of samples collected showed acetone concentrations ranged from 10 to 57 µg/kg. Because the quantitation limit for acetone is 10 µg/kg and nearly all samples showed acetone in association with method blank contamination, it is assumed that these low levels are a result of laboratory contamination. Boring W10-06(C) also contained 170 mg/kg TPHC at the 3-foot depth. All other organic contaminants were at or below the quantitation limit or were found in the associated laboratory method blank. Only one sample showed bis(2-ethylhexyl)phthalate above quantitation limits: the 6-foot depth sample from W10-5(A1) had a concentration of 730 µg/l.

Low levels of inorganic compounds were found in six samples collected from two well borings. Aluminum, calcium, iron, sodium, potassium, and magnesium are major components of soil materials, and because they are naturally occurring, they will not be included in the discussion unless excessive amounts were reported. Baseline concentrations are shown in Table 3.5-1.

Barium was detected above the NAS baseline of 220.4 mg/kg in seven samples. The 1-foot depth was 255 mg/kg, the 3-foot depth was 131 to 214 mg/kg, the 5-foot depth was 197 mg/kg, and the 6-foot depth sample from W10-05(A1) had a concentration of 754 mg/kg. This latter concentration is nearly four times the NAS baseline; however, the USGS baseline is 700 mg/kg to 5,000 mg/kg.

Beryllium was detected above the Hetch-Hetchy baseline concentration of 0.8 mg/kg in the 3-foot depth (1.2 mg/kg), 5-foot depth (1.6 mg/kg), and 7-foot depth (1.2 mg/kg) from W10-06(B4). None of these levels are above the NAS baseline of 3.7 mg/kg.

Chromium was detected above the Hetch-Hetchy baseline concentration of 60 mg/kg in one sample taken from the 3-foot depth (72.5 mg/kg) in W10-05(A1). This level is below the NAS baseline of 76.5 mg/kg.

Copper was detected above the MW-18 baseline concentration of 44 mg/kg in three samples. The 3-foot and 5-foot depth samples in W10-06(C) contained 61.7 mg/kg and 67.0 mg/kg, respectively, and the 1-foot depth sample in W10-05(A1) contained 54.2 mg/kg. The levels are within or slightly above the NAS baseline of 56.7 mg/kg and are considered within natural variation.

Mercury was detected above the Hetch-Hetchy baseline of 0.1 mg/kg in the 7-foot depth sample from W10-06(C). This concentration (0.8 mg/kg) is only slightly above the NAS baseline of 0.5 mg/kg.

Nickel was detected above the baseline concentration of 47 mg/kg in four samples. The 1-, 3-, >5-foot depths from W10-05(A) contained 57.7 mg/kg, 64.3 mg/kg, and 57.3 mg/kg, respectively. The 5-foot depth in W10-06(C) contained 52.0 mg/kg. These levels are not above the NAS baseline of 88.5 mg/kg.

In summary, samples from Site 10 well borings do not show significant levels of contamination of soils by either organic or inorganic compounds. However, additional soil sampling should be conducted near W10-6(C) to determine if significant soil contamination by TPHC is present.

Ground Water

Acetone was the only VOC found in ground water above quantitation limits and/or not associated with method blank contamination (Tables 13.4-5 and 13.4-6). The compound was found slightly above the quantitation limit of 10 µg/l in well W10-02(A1) at 11 µg/l and in W10-03(B2) at 16 µg/l. Acetone was also detected frequently in association with method blank contamination.

Bis-2(ethylhexyl)phthalate was detected in one sample from W10-05(A1) at 11 µg/l, just above the quantitation limit of 10 µg/l. This compound was not found in any other Site 10 well sample.

TPHC was detected in the first round sample from well W10-06(C) at 372 mg/l.

TPHC was not detected in any other samples from this or any other Site 10 wells. Because TPHC was observed only once and during the first sampling round, it is possible that these chemicals were introduced during the well drilling process.

Seven inorganic analytes were found at concentrations above quantitation levels in well W10-05(A). Common salt water and ground water components that are found in the Site 10 A aquifer well at concentrations typical of the station include calcium, iron, magnesium, manganese, and sodium.

Silver was the only other metal found above quantitation limits in the A aquifer well samples. The first round sample had a concentration of 33.1 $\mu\text{g/l}$; however, no succeeding samples had silver above quantitation limits and thus the first occurrence is not considered representative of ground water contamination.

Monitoring well W10-06(C) contained four inorganic analytes above quantitation limits. These four are calcium, magnesium, manganese, and sodium. The concentration ranges of these elements are shown in Table 13.4-6. Concentrations of these common saltwater and ground water constituents are lower in the C aquifer than in the A aquifer, reflecting the lesser degree of salt water intrusion in the C aquifers. Mercury was detected in one sample at 1.4 $\mu\text{g/l}$, and nickel in one sample at 13.2 $\mu\text{g/l}$. The concentrations shown in the table are typical of the C aquifer at the station.

In summary, ground water samples do not show contamination by organic or inorganic material in A, B, or C aquifer wells.

14.0 ENGINE TEST AREA - SITE 11

14.1 DESCRIPTION AND HISTORY

The Engine Test Area site is located approximately 500 feet north of the intersection of Patrol Road and Zook Road and lies between the eastern edge of the runway and Devil's Slough (Figure 14.1-1). The site is used to test aircraft engines under power. The site is fenced and covered by both concrete and asphalt that constitute a pad approximately 200 by 200 feet. There is a small drainage depression that drains waste oils, hydraulic fluids, and fuels from the center of the pad to the southern edge of the pad. During past tests, fluids may have run onto the adjacent soils causing a stain south of the pad. The stained area is approximately 45 feet by 75 feet. It is unknown how long the Engine Test Area has been in use, how frequently it has been used, or the quantity of fluids that has run off the pad.

14.2 FIELD INVESTIGATION

The investigation activities for Site 11 included:

- Installation of monitoring wells.
- Collection of surface soil samples and shallow borehole soil samples.
- Ground water and soil chemicals analysis.

14.2.1 Ground Water Monitoring Wells

Two monitoring wells, [W11-01(A1) and W11-02(A1)] were installed at this site. The purpose of these wells is to monitor the uppermost aquifer beneath the site for contaminants. The monitoring wells, shown on Figure 14.1-1, were drilled to depths of 25 and 80 feet, respectively. The boring for well W11-01(A1) was subsequently backfilled with bentonite to a finished depth of 20 feet. Both wells monitor the A1 subaquifer, with W11-01(A1) screened from 15-20 feet bls and well W11-02(A1) screened from 17.5 to 22.5 feet bls.

Boring logs with well construction diagrams are presented in Appendix I of the December 1988 Quarterly Report (IT, 1988e). A summary of well construction details is also given in Table 2.3-2.

14.2.2 Soil Samples

Soil samples from the monitoring well borings were collected and analyzed from the vadose zone. Additionally, a total of 10 surface and 10 shallow soil borings samples were collected on 20-foot centers to the south of the concrete slab (Figure 14.1-1).

Locations of the soil borings are shown in Figure 14.1-1. Soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, TPHC, and oil and grease. Complete analytical results are included in Section 11.0, Appendix B, of the August 1989 Quarterly Report (IT, 1989c). A summary compilation is presented in Appendix C of this report.

14.2.3 Ground Water Samples

Four rounds of ground water samples were collected and analyzed for VOCs, PCBs, pH, specific conductivity, major anions, TDS, metals, BNAs, and TPHC. Complete analytical results are available in Section 11.0 of Appendix B in the August (IT, 1989c), November 1989 (IT, 1989d) and the February 1990 (IT, 1990) Quarterly Reports. A summary compilation is given in Appendix D of this report.

14.2.4 Water Level Measurements

Water level measurements were recorded from both Site 11 wells over a period of one year, extending from November 1988 to October 1989. Data from these measurements have been compiled into hydrographs illustrated in Appendix A.

14.3 HYDROGEOLOGY

14.3.1 Site Geology

The geology of Site 11 is typical of the adjacent landfill study sites, Site 1 and Site 2. As expanded discussion of local geology is provided in Sections 4 and 5.

14.3.2 Hydrology

Surface Water

Site 11 is bordered to the east by Devils Slough; however, no surface water features exist on the site.

See Section 4 (Site 1) and Section 5 (Site 2) for a detailed description of the hydrology of Site 11.

Ground Water

The upper A1 subaquifer underlying the site consists of sandy silt or silty sand. This aquifer is about 9 feet thick and extends under the site. At greater depths there does not appear to be an aquitard between the lower portion of the A and the A2 subaquifer [W11-02(A) on Figure 14.1-1].

There are no monitoring wells in the B or C aquifers. Although W11-01(A1) was drilled to 80 feet, the well was backfilled and the screen installed in the upper portion of the A1 subaquifer (17.5 to 22.5 feet below land surface). The location of the ground water monitoring wells are shown on Figure 14.1-1.

A Aquifer - The A aquifer can be divided into two water bearing units, the A1 subaquifer at about 13 to 25 feet and the A2 subaquifer at about 33 feet to over 80 feet. No data exists on the hydraulic conductivity of the material beneath Site 11. The boring log for well W11-02(A1) shows aquitard material at 26 to 33 feet and from 38 to 40 feet.

Based on September 1988 data, the ground water in the A aquifer at the Site moves in a southerly direction toward the culvert pumping station located at Site 2. The pumping station discharges water to a perimeter canal which eventually goes to Guadalupe Slough in order to prevent flooding of the lowland areas. The slope of the potentiometric surface was about one foot for every 170 feet (0.006) of horizontal distance. The slope of the gradients and the direction of ground water flow indicate that sea water could easily move into the area from the north. The impact of the pumping station is illustrated by potentiometric surface maps in Appendix B of this report.

14.4 NATURE AND EXTENT OF CONTAMINATION

14.4.1 Sources

Runoff of precipitation and hydraulic cleaning of the slab, which drains to a grassy area to the south, could result in the transport of residual spilled

fuel products and lubricants to local soils and ground water. Previous shallow soil samples collected by the CRWQCB from an oil-stained area adjacent to the concrete slab contained 570 mg/kg of lead and 250 mg/kg of zinc, plus cadmium, copper, chromium, and nickel in the 20 to 50 mg/kg range (verbal communication between T. Berkins and K/J/C, August 21, 1987). These findings prompted the initiation of this study.

No underground tanks were identified at or near the Engine Test Area. The only known or suspected source of hydrocarbons and other chemicals are the Engine Test Area itself or the Golf Course Landfill at Site 2, which lies approximately 1,000 feet to the south.

14.4.2 Review of Chemical Analyses

Surface Water

There are no surface water features at Site 11.

Soils and Sediments

A total of 28 soil samples were analyzed for volatile organic compounds and BNAs. Samples were collected from 1-, 3-, 5-, and >5-foot depths. Plate E-1 contained in Appendix E depicts the distribution of detected compounds at the site. The statistical evaluation of analytical results is presented on Tables 14.4-1 through 14.4-4. The most frequently detected compounds were the common laboratory contaminants, acetone, methylene chloride, and 2-butanone. In most cases, each of these detections was associated with method blank contamination.

Oil and grease was found in 25 borings and ranged from 2 mg/kg in SB11-01 (0.5-foot) to 9,600 mg/kg in GSB11-18 (0.5-foot). Oil and grease was found at 5-foot or greater depth in 11 samples and ranged from 2 mg/kg in SB11-07 to 530 mg/kg in GSB11-18.

Other organic compounds were found in three other borings. SB11-01 contained benzo(a)anthracene (800 µg/kg), benzo(a)pyrene (640 µg/kg), benzo(b)fluoranthene (1,100 µg/kg), bis(2-ethylhexyl)phthalate (480 µg/kg), chrysene (860 µg/kg), and fluoranthene (1,900 µg/kg). All of the above compounds were found

at the 3-foot depth. Bis(2-ethylhexyl)phthalate (620 µg/kg) was found at the 5-foot depth in SB11-04 (620 µg/kg), and GSB11-11 at the 0.5-foot (950 µg/kg), and 5-foot (4,500 µg/kg). 1,1,1-trichloroethane (16 µg/kg) was found at the 5-foot depth in SB11-08.

A statistical summary of metals to nonmetal elements detected in soils from Site 11 is presented in Tables 14.4-1 through 14.4-4. The distribution of detected compounds is depicted on Plate E-2.

The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed on Table 3.2-1. A review of soils data suggests that most inorganics are present above the estimated baseline and are present in the 1-foot and 5-foot samples. Elements that exceed the baselines significantly are arsenic, barium, lead, and zinc.

Arsenic was detected in 23 out of 28 soil samples and ranged from 2.2 to 25.2 mg/kg. GSB11-18 contained 25.2 mg/kg at the 0.5-foot depth and 12.2 mg/kg at the 5-foot depth. GSB11-19 contained 14.5 mg/kg at the 0.5-foot depth and 11.6 mg/kg at the 5-foot depth. NAS baseline for arsenic is 8.8 mg/kg.

Barium was detected above the NAS baseline of 220.4 mg/kg in 8 out of 28 soil samples and ranged from 48.7 mg/kg to 1,470 mg/kg. Five of the soil borings ranged from 222 mg/kg to 278 mg/kg, slightly above the NAS baseline of 220.4 mg/kg. GSB11-04 was 303 mg/kg, GSB11-12 was 442 mg/kg, and GSB11-05 was 1,470 mg/kg. The three high results were all from the 0.5-foot depth.

Copper was detected above NAS baseline (56.7 mg/kg) in five soil samples which ranged from 57.7 mg/kg to 109 mg/kg. GSB11-11 was 57.7 mg/kg at the 5-foot depth, GSB11-02 was 76.5 mg/kg at the 0.5-foot depth, GSB11-07 was 107 mg/kg at the 0.5-foot depth, and GSB11-03 was 109 mg/kg at the 0.5-foot depth.

Lead was detected in 17 soil samples above the NAS baseline of 28.3 mg/kg. Concentrations ranged from 30.4 mg/kg in GSB11-15 at the 5-foot depth to 126 mg/kg in GSB11-11 also at the 5-foot depth. Lead was found in 12 samples from the 0.5-foot depth and from six samples at the 5-foot depth.

Vanadium was detected above the NAS baseline (78.2 mg/kg) in 7 soil samples which ranged from 84.6 mg/kg in SB11-08 (5-foot depth) to 152 mg/kg in SB11-02 (0.5-foot depth). The compound was found in seven samples from the 0.5-foot depth and in four samples from the 5-foot depth.

Ground Water

A total of 12 ground water samples were collected and analyzed for BNAs, VOCs, PCBs, metals, and nonmetals. Samples were taken from two wells at Site 11, W11-01(A1) and W11-02(A1). The distribution of detected compounds in the ground water are shown on Plates E-11 and E-12 in Appendix E.

The only organic compound detected was the common laboratory contaminant methylene chloride which ranged from 6 ug/l to 65 ug/l. The detections in samples from both wells were associated with method blank contamination.

Several metals and nonmetals were consistently above the quantitation limit. These elements and compounds are presented on Table 14.4-5. Naturally occurring inorganic constituents in the soils (aluminum, calcium, sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has also contributed to the natural degradation of the water quality. The naturally occurring elements and compounds will not be discussed in this text.

Inorganics found in the ground water include barium, cadmium, chromium, copper, iron, lead, manganese, mercury, silver, thallium, vanadium, and zinc. Barium was found in both wells in early rounds of sampling, but was not detected consistently above quantitation limits. Barium levels above quantitation limits ranged from 330 ug/l to 397 ug/l. These levels are well below the DWR background range of up to 710 ug/l. Cadmium was found inconsistently in W11-02(A1) from 23 ug/l to 288 ug/l. Chromium was found in W11-01(A1) and W11-02(A1) at 17 ug/l and 18.9 ug/l, respectively. Copper was found in W11-01(A1) at 40 ug/l and in W11-02(A1) ranging from 30 ug/l to 210 ug/l. Iron was found in both wells and ranged from 1,770 ug/l to 24,700 ug/l. Lead was found in one sample from W11-01(A1) at 26 ug/l. Manganese was found in both wells and ranged from 6,720 ug/l to 10,100 ug/l. Mercury was found in one sample from W11-01(A1) at 0.6 ug/l. Silver was found in W11-

01(A1) ranging from 28 µg/l to 88 µg/l and in W11-02(A1) ranging from 28 µg/l to 714 µg/l. Thallium was found in W11-02(A1) in one sample at 60 µg/l. Vanadium was found in W11-02(A1) in one sample at 390 µg/l. Zinc was found in W11-01(A1) from 41 µg/l to 469 µg/l and in W11-02(A1) at 345 µg/l.

Ground water testing did not indicate organic contamination to the A aquifer. Although several metals were detected, none were detected consistently and most were single events and at low levels. Therefore, the occurrences of these metals are not considered to be indicative of ground water contamination. Monitoring wells were placed based on a general knowledge of ground water flow at the station. However, the Phase I data revealed that Site 11 wells are upgradient of the main potential source area.

Soils at the Engine Test Area appear to be a potential source of ground water contamination. Perimeter soil borings showed low level contamination by oil and grease and therefore additional sampling will be needed to determine the extent of contamination. Because monitoring wells were placed upgradient of the potential source area and the extent of soil contamination has not been defined, additional monitoring well information is required to make a final determination of the extent of ground water contamination.

15.0 FIRE TRAINING AREA - SITE 12

15.1 DESCRIPTION AND HISTORY

The Fire Fighting Training Area lies adjacent to the northwest edge of the NAS Moffett Field runway, approximately 1,500 feet north of Hangar 1 between Zook Road and the aircraft taxiway, (Figures 1.4-1 and 15.1-1). The site consists of a bermed pit, approximately 65 feet by 65 feet, which contains a mock-up of a plane for use as a fire fighting training target. The berm is approximately 1-foot high. A 500-gallon aboveground fuel tank is located approximately 120 feet north of the pit and contains waste fuel for use in training. Previously, waste solvents were mixed with the waste fuels.

Until 1987, the target plane was periodically covered with waste fuel (JP-4, JP-5, and diesel) and ignited (NEESA, 1984). The fire crews extinguished the fire with water and/or firefighting chemicals containing Halon 1211 (bromochlorodifluoromethane), potassium bicarbonate, and an aqueous film-forming foam of unknown composition.

The bermed firefighting pit has been in use since the 1950s. Since 1987, however, no fires have been set in the pit. The residue from burned fuels and firefighting chemicals remains in the pit. Evaporation and percolation are the suspected processes by which the materials may leave the pit area. However until 1980, occasional overflow during the rainy season resulted in some external discharge which was estimated to be a maximum of 300 gallons per year (NEESA, 1984). Since 1980, the residue has reportedly been pumped back into the waste fuel tank (NEESA, 1984).

In 1987, a consulting firm (Harding-Lawson Associates) dug an 8.5-foot deep pit immediately north of the fuel storage tank. Soil analyses results showed concentrations as high as 2,200 ppm of TPHC (HLA, 1987b).

15.2 FIELD INVESTIGATION

The purpose of the investigation at Site 12 was to characterize the composition and extent of chemicals migrating from the site into soils and ground water. The investigation activities for Site 12 included:

- Installation of three monitoring wells
- Sampling 12 shallow soil borings
- Conducting a soil gas survey
- Analyzing ground water and soil samples
- Measuring water levels.

15.2.1 Ground Water Monitoring Wells

Three A aquifer ground water monitoring wells, W12-01(A2), W12-02(A2), and W12-03(A1), were installed and developed in December 1988. Monitoring well W12-01(A2) is located upgradient of the site and wells W12-02(A2) and W12-03(A1) were installed downgradient of the training area near the fuel storage tank. The monitoring wells are shown in Figure 15.1-1. Boring logs for these wells are presented in Appendix I of the December 1988 Quarterly Report (IT, 1988e). Well construction information is included in the boring logs and completion details are listed on Table 2.3-2.

15.2.2 Soil Borings

Twelve soil borings were drilled at Site 12 to determine the nature and extent of shallow soil contamination. Boring locations are shown in Figure 15.1-1. Borings were abandoned by backfilling with a bentonite cement grout.

15.2.3 Soil Gas Survey

Soil gas sampling was completed along four transect lines. Sampling stations were placed about every 50 feet along each line. Soil gas samples were collected from a depth of about 5 feet bls and analyzed for total ionizable compounds using TIP sampling and methods. Select samples were also analyzed by the GC method.

15.2.4 Soil Samples

Soil samples were obtained from monitoring well borings at depths of 1-, 3-, and 5-foot depths (all above the water table). Eight shallow soil borings were placed uniformly around the periphery of the Training Area and four soil borings were placed around the fuel tank as shown in Figure 15-1.1. These borings were also sampled at approximate depths of 1-, 3-, and 5-foot depths. Soil samples were analyzed for VOCs, pH, priority pollutant metals,

PCBs, BNAs, TPHC, oil and grease, and tetraethyl lead. Intermediate depth samples were also analyzed for dioxins. Preliminary analytical results are included in the August 1989 Quarterly Report (IT, 1989c) and are summarized in Appendix C of this report.

15.2.5 Ground Water Samples

Three ground water monitoring wells were installed in the A aquifer at Site 12. Quarterly water samples were collected and analyzed to determine contaminant concentration. Ground water samples were analyzed for VOCs, PCBs, pH, specific conductivity, major ions, TDS, dioxins, tetraethyl lead, and TPHC. Ground water samples collected from previously installed MEW well 83B1(A2) were analyzed for VOCs, ions, and TDS. Preliminary analytical results were reported in the quarterly reports, starting with August 1989 (IT, 1989c), and are summarized in Appendix D of this report.

15.2.6 Water Level Measurements

Monthly water-level measurements were taken at the three monitoring well sites from November 1988 through October 1989. Water-level measurements were used to construct quarterly potentiometric surface maps for the A aquifer and to determine ground water gradients. The quarterly potentiometric surface maps are presented in Appendix B. The monthly data are plotted as hydrographs in Appendix A of this report.

15.3 HYDROGEOLOGY

15.3.1 Site Geology

The stratigraphy of Site 12 is interpreted from the three monitoring wells installed by IT. These wells penetrate only the A aquifer and the A1/A2 aquitard. The sediments at this site are composed of interbedded gravel, sand, silt, and clay.

The A1/A2 aquitard, underlying the A1 subaquifer, is a silty clay to clayey silt, with some gravel, dark greenish gray to yellowish brown in color, non-plastic, and stiff to very stiff. The penetrated thickness of the unit ranges from 3 to 5 feet.

The A aquifer is a thin sand and/or gravel unit overlain by a sequence of interbedded silt and clay with some minor amounts of sand. The thin sand and/or gravel unit is comprised of fine to medium sands and/or gravel, with some silt and clay, and is yellowish brown in color. This unit represents the screened interval for all wells at the site.

The overlying interbedded units consist of silt and clay with some minor sand and extends to the surface.

15.3.2 Hydrology

Surface Water

No surface water exists at the site.

Vadose Zone

Water was first encountered in a silty clay at 12 feet bls in wells W12-01(A2) and W12-02(A2). In well W12-03(A1) water was encountered in a clayey silty sand at 7 feet bls. The vadose zone in the Site 12 area is composed of interbedded clay and silt with minor units of fine sand. Clay is the predominant lithology. The vadose zone is approximately 7 to 12 feet thick.

Ground Water

Only the A aquifer and A1/A2 aquitard are penetrated in the Site 12 area. The aquifer is predominately sand and gravel with minor silt and clay components. Comparison between depth to water during drilling and monthly water-level measurements indicates that the aquifer in this area acts as a confined system.

Quarterly potentiometric surface contours of the A aquifer for the west side of the station, which includes Site 12, can be found in Appendix B of this report.

Ground water flow in the A aquifer is northerly with a gradient of approximately 0.003 ft/ft. No change in flow direction or gradient was observed during the 1 year of water-level measurements. Hydrographs illustrating

monthly water level changes are included in Appendix A of this report. Seasonal water level variations are approximately 2 feet and may be attributed to seasonal precipitation variation. No B- or C-aquifer wells were installed at this site.

15.4 NATURE AND EXTENT OF CONTAMINATION

15.4.1 Sources

The primary contamination source at Site 12 is due to firefighting training activities. At the site, waste aviation fuel was sprayed over the target area and ignited. Firefighting crews would then extinguish the fires as part of the training exercises. An additional source of contamination at Site 12 is the firefighting fuel storage tank north of the training area.

15.4.2 Review of Chemical Analyses

The following discussion presents a review of chemical data obtained from the Phase I investigation sampling activities. A summary compilation of soil and water analytical data is included in Appendices C and D, respectively.

Soils

Soil samples were collected from the areas around the firefighting training area and the firefighting fuel storage tank. Three samples were collected from each soil boring and monitoring well site, resulting in a total of 45 soil samples. Statistical analyses of sample data for the 1-, 3-, and 5-foot depths are presented in Tables 15.4-1 through 15.4-3. These tables show analytes detected above quantitation limits and do not include duplicate sample results.

A total of five VOCs were detected above quantitation limits in Site 12 soil samples. Acetone, methylene chloride, and 2-butanone were reported in all samples. These compounds were found at low concentrations and were either estimated at below the quantitation limits or were found in association with method blank contamination. The three compounds are common laboratory contaminants and their presence in sample analysis is probably not indicative of soil contamination.

Toluene and total xylenes were also found in Site 12 soil samples. Both of these compounds were found in the 1- and 3-foot depths from boring SB12-07. Concentrations of 17 ug/kg at the 1-foot depth and 12 ug/kg at the 3-foot depth were reported for toluene, and 30 ug/kg at the 1-foot depth and 15 ug/kg at the 3-foot depth were reported for xylenes. Toluene was also reported in several other samples but in quantities below quantitation limits and may be associated with method blank contamination. Total xylenes were found in the 1-foot depth in SB12-09 at 9 ug/kg. These compounds are common constituents of aviation and motor fuels which may have been used at the site.

A total of 14 BNA compounds were found in the soil samples from this site. All but two of these occurred in the 1-foot depth sample from SB12-12. Concentrations of these compounds were up to 3,700 ug/kg. The compounds and their concentrations are listed in Table 15.4-1. Most of these compounds were also reported in the samples from SB12-01. Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were also found in the soil samples. The first compound was found in one sample each from SB12-05, SB12-11, and W12-03(A1). The concentrations ranged from 400 to 680 ug/kg. Di-n-butylphthalate was found in one sample from W12-02(A2) and in a sample and duplicate from W12-01(A2) with concentrations of 480 to 1,400 ug/kg. Both samples from W12-01(A2) had method blank contamination reported with the results.

Petroleum hydrocarbons were found in three samples: the 1-foot depth in SB12-09 at 610 mg/kg, and from the 5-foot depth in SB12-11 and W12-03(A1) at 1,400 mg/kg and 530 mg/kg, respectively.

Oil and grease were found in five samples. The highest concentration, 16,000 mg/kg, was from the 3-foot depth in W12-02(A2). In the sample from the 1-foot depth 3 mg/kg was found and none was detected from the 5-foot depth at W12-02(A). In a contrasting distribution, the 3-foot sample from W12-03(A1) had 3 mg/kg, while the 1- and 5-foot depth samples had 680 and 570 mg/kg, respectively.

The occurrence of organic compounds at Site 12 indicates that soil contamination is unevenly distributed with different chemical compounds occurring at

various locations and depths (Plate E-9). Most of the contamination, however, occurs around the fuel tank area, not the fire fighting training area.

As noted in previous sections, several elements occur naturally at variable levels in soils. The natural occurrences of these elements are found at levels up to two to four times the averaged NAS baseline. At Site 12, these include the following elements:

- Aluminum
- Barium
- Calcium
- Iron
- Magnesium
- Manganese
- Potassium
- Sodium.

These elements were found at maximum concentrations of less than twice the NAS baseline with one exception. Aluminum was found at the 3-foot depth in W12-03(A1) at 166,000 mg/kg. Samples from the 1- and 5-foot depths from this well boring, however, had concentrations of less than 30,000 mg/kg. The reason for the elevated concentration in a mid-depth sample taken from the unsaturated zone is unclear. Other elements found above the baselines for the area are discussed below.

Beryllium was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in 10 samples (including one duplicate), though none were above the NAS baseline of 3.7 mg/kg.

Chromium was detected in 44 samples, of which 24 were above the Hetch-Hetchy baseline of 60 mg/kg. Only seven samples were above the NAS baseline of 76.5 mg/kg, and these were only slightly elevated, with a maximum concentration of 84.3 mg/kg reported.

Cobalt was detected in 42 samples, with 9 samples above the NAS baseline of 18.6 mg/kg. The maximum concentration reported was 23.3 mg/kg at the 1-foot depth, only slightly greater than the baseline.

Copper was detected in 44 samples; 26 were above the MV-18 baseline of 44 mg/kg, and 12 were above the NAS baseline of 56.7 mg/kg. The maximum concentration reported for all but two samples was 88.4 mg/kg. Two samples had unusually high concentrations. The 3-foot depth in SB12-02 had 6,010 mg/kg and the 5-foot depth in SB12-12 had 11,800 mg/kg. These locations are at opposite ends of the site and the reason for such high concentrations of copper is unclear. These two samples also contained high concentrations of zinc and, as discussed in Section 10.4, may represent the leaching potential of sample preparation extractants.

Lead was detected in 44 samples, but only one soil sample was above the NAS baseline of 28.3 mg/kg. The 1-foot depth sample in SB12-02 had 47.1 mg/kg. This concentration is not significantly greater than the NAS baseline and is within the baselines for the Hetch-Hetchy and MW-18.

Mercury was detected above the Hetch-Hetchy baseline of 0.1 mg/kg in four samples. Mercury levels ranged from 0.2 mg/kg to 0.4 mg/kg and is within NAS baseline.

Nickel was found in samples at levels above the Hetch-Hetchy baseline of 47 mg/kg. Two samples were above the NAS baseline of 88.5 mg/kg. These samples had concentrations of 89.6 at the 1-foot depth and 89.0 mg/kg at the 3-foot depth and were only slightly above the NAS baseline.

Silver was found in 2 samples above the MW-18 baseline of 0.4 mg/kg. Only one sample was above the NAS baseline of 5 mg/kg. The 3-foot depth sample from well W12-02(A2) had a concentration of 118 mg/kg. The single occurrence of silver at a high concentration is not understood.

Thallium was reported in one sample at a concentration of 0.3 mg/kg which is slightly above the method detection limit 0.2 mg/kg.

Vanadium was detected above the NAS baseline of 78.2 mg/kg in two samples. The 1-foot depth in W12-02(A2) and W12-03(A1) had 91.8 mg/kg and 80.4 mg/kg.

Zinc was found in three samples above the NAS baseline of 104.1 mg/kg. The 1-

foot depth in SB12-02 had 115 mg/kg, the 3-foot depth sample had 2,590 mg/kg, and the 5-foot depth sample in SB12-12 had 4,880 mg/kg. The reason for these high concentrations is unclear. However, these are the same samples which contained high copper concentrations, and the high concentrations may be an indication of leaching of brass in sample preparation.

In summary, with the exception of copper, zinc, silver, and perhaps the one occurrence of aluminum, levels of metal to nonmetal elements do not occur in concentrations indicative of contamination. The occurrences of the four suspect elements appears to be limited to isolated areas of small extent. Summary analytical results for a soil analysis are contained in Appendix C of this report.

Soil Gas Surveys

Soil gas surveys conducted at Site 12 revealed high concentrations of volatiles between the tank and the firefighting training area (Figure 15.4-1). Two other sampling stations near the firefighting training area had TIP readings of 20.8 and 26.9 ppm. Other sampling stations at Site 12 had TIP values less than 10 ppm. Soil gas sampling location TL-5 AS1, shows high concentrations of 1,1,1-TCA and TCE, with lesser amounts of 1,1-DCA, benzene, toluene, and xylene. Sample location TL-5 AS3 showed low concentrations of toluene and xylene. Sample location TL-6 AS2 showed high concentrations of 1,1,2-TCA, TCE, 1,1-DCA, and low concentrations of benzene, toluene and xylene. Sample location TL-40 AS1 showed contamination with TCE and 1,1,2-TCA. Results of soil gas analyses by GC are presented in Table 15.4-4. TIP transect data are shown in Figure 15.4-1.

Ground Water

Six rounds of ground water samples were collected from the one A1 and two A2 subaquifer Phase I wells at Site 12. All samples were analyzed for VOCs, BNAs, PCBs, metals, dioxins, tetraethyl lead, and TPHC. The first four rounds of samples were also analyzed for major ions and TDS. Four quarters of ground water samples were also collected from MEW well 83B1(A2). This well is cross-gradient from the site. Samples from this well were analyzed for VOCs, ions, and TDS only.

Only two VOCs, acetone and methylene chloride, were detected consistently in Site 12 monitoring wells. Only methylene chloride was detected above quantitation limits, and all of these detections were associated with method blank contamination. Other occurrences of acetone and methylene chloride were estimated below the quantitation limits and/or were associated with method blank contamination. No other organic compounds were detected in Site 12 well samples. A summary compilation of analytical data for Site 12 ground water samples is included in Appendix D of this report, and a statistical analysis of compounds detected above the quantitation limits is presented in Table 15.4-5.

Five elements which are common constituents of sea water or local ground water were detected consistently in the three A aquifer wells. These include calcium, iron, magnesium, manganese, and sodium. The concentration ranges of these elements are shown in Table 15.4-5. The ranges are similar to those found in the A aquifer wells at the nearby Site 9 and are typical of the ground water for the station.

Two other metals were found at concentrations above quantitation limits; however, each was detected only one time. Mercury and zinc were each found in different samples from W12-02(A2) at concentrations of 1.9 and 54.9 $\mu\text{g/l}$, respectively. The single occurrences of these elements in six rounds of sampling are not indicative of ground water contamination.

Summary

In summary, organic compound contamination of soils is predominantly in the fuel tank area of Site 12, at various depths and locations. While toluene and total xylenes were found in both soils and soil gas, several chlorinated VOCs were found in the soil gas survey that were not found in the soil samples. Of the four chlorinated solvents found in the soil gas, only one, 1,1-DCA, was reported in water samples and it was in trace amounts (see analytical results in Appendix D). One other chlorinated VOC reported in soil gas, 1,1,1-TCA, was reported in two soil samples at trace amounts (see analytical results in Appendix A) of this report.

Results of sample analysis also show that there may be isolated areas of soil

contamination by copper, silver, zinc, and possibly aluminum, though the occurrences are sporadic in distribution.

Ground water contamination at Site 12 was not identified by the Phase I investigation. No organic compound or inorganic element was found consistently in any of the monitoring wells (except for methylene chloride). This includes one A1 aquifer monitoring well placed near, and downgradient of, the fuel tank area.

Removal activities are currently planned by the Navy for Site 12. The scope of this work includes three additional A aquifer wells, additional soil borings, and two trenches near the fuel tank area. The results of this work will determine the need for further investigation at this site.

16.0 EQUIPMENT PARKING AREA - SITE 13

16.1 DESCRIPTION AND HISTORY

Site 13, the Equipment Parking Area, is a concrete/asphalt support vehicle parking lot which covers approximately 7,500 square feet and is located between the east side of Building 142 and Macon Road (Figure 16.1-1). Building 142 is used for repair and maintenance of aircraft ground support equipment.

Waste and industrial wastewater from spills, leaks, and equipment washing were flushed into a surface drainage ditch adjacent to the concrete/asphalt parking area. The ditch flows into a main north-south storm drain.

16.2 FIELD INVESTIGATION

The investigation activity for Site 13 included:

- Installation of four shallow soil borings
- Soil sample chemical analyses.

16.2.1 Soil Borings

Three shallow soil borings were installed in the north-south trending storm drain and a fourth boring was installed in the center of the east-west trending drainage channel. Approximate locations of these borings are shown in Figure 16.1-1.

16.2.2 Soil Samples

Soil borings were sampled at approximate depths of 1 and 5 feet. Soil samples were analyzed for VOCs, pH, metals, BNAs, TPHC, and oil and grease. Preliminary analytical results were included in the August 1989 Quarterly Report (IT, 1989c).

16.3 HYDROGEOLOGY

16.3.1 Site Geology

No wells or geophysical borings were drilled at Site 13 to provide site specific information on the geology. The stratigraphy is assumed to be

similar to that of the nearby sites 5 and 7, and is shown on cross-section C-C' (Figure 3.3-4).

16.3.2 Hydrology

Surface Water

The entire surface of the Equipment Parking Area (Site 13) is covered with concrete and/or asphalt which drains to the north into an asphalt lined drainage channel and east into a storm drain. When precipitation falls on the parking lot all runoff is diverted to the north or east. Runoff which reaches the east/west drainage channel flows east into the north-south storm drain.

Vadose Zone

Because of the concrete and/or asphalt pad at the site, little is known about the vadose zone. See Section 10.3 (Site 7) for information about the vadose zone.

Ground Water

No wells were installed at this site, but because of its proximity to Sites 6, and 7 the information contained in Sections 9.3 and 10.3 also applies to this site.

16.4 NATURE AND EXTENT OF CONTAMINATION

16.4.1 Sources

Operations including the repair and maintenance of aircraft equipment at the Equipment Parking Area located northeast of Building 142 are the potential sources of contamination at Site 13. Fuel and lubricant spilled on the concrete and asphalt pavement are flushed from the paved surfaces into ditches or drains. There is a sump (Sump 63) located to the southwest of Building 142 which may also act as a source. This sump contained stripping/vehicle steam cleaning wastes and is discussed in Section 18 (Site 15).

Four shallow soil borings were installed at Site 13 to characterize the extent and level of contamination into the vadose zone.

16.4.2 Review of Chemical Analysis

The following discussion presents a review of chemical data obtained from the analyses of the soil boring samples. The summary compilation of analytical data is included in Appendix C of this report.

Soils and Sediments

A total of eight soil samples were analyzed for VOCs, BNAs, TPHC, oil and grease, and metals. Samples were collected from 1- and 5-foot depths. The analytical results are presented in Tables 16.4-1 and 16.4-2. The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each sample was associated with method blank contamination. Methylene chloride was detected in all eight samples and acetone was detected in three samples.

TPHC was found in one sample. The sample was from the 5-foot depth in SB13-04 at 110 mg/kg. Oil and grease was found in all samples and ranged from 6 mg/kg to 1,150 mg/kg. In general, higher concentrations occurred in the 5-foot depth samples.

Bis(2-ethylhexyl)phthalate was found at the 5-foot depth in SB13-01 at 650 ug/kg.

A total of eight soil samples were analyzed for inorganic compounds. A summary of metals and nonmetals detected in soils from Site 13 is presented in Tables 16.4-1 and 16.4-2. The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed on Table 3.2-1. A review of soils data indicates that most of the inorganics detected are present above the established baseline. Elements that exceed the baseline are: arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, nickel, vanadium, and zinc. Naturally occurring inorganic constituents within the soils - aluminum, calcium, sodium, potassium, manganese, and magnesium - will not be discussed.

Arsenic was detected in one sample above the Hetch-Hetchy (6.3 mg/kg) and NAS (8.8 mg/kg) baselines from the 5-foot depth in SB13-03 at 10.2 mg/kg.

Barium was detected above the NAS baseline of 220.4 mg/kg in five samples.

Samples detected above the baseline from the 1-foot depth ranged from 229 mg/kg to 290 mg/kg and samples from the 5-foot depth ranged from 172 mg/kg to 447 mg/kg.

Cadmium was detected above the Hetch-Hetchy (4 mg/kg), MV-18 (3 mg/kg), and NAS (3.5 mg/kg) baselines. Cadmium was found in two borings (SB13-02 and SB13-03) at the 1-foot depth at 6.8 mg/kg and 6.3 mg/kg, respectively. SB13-01 contained 4.4 mg/kg at the 5-foot depth.

Chromium was detected in eight soil samples above the Hetch-Hetchy baseline (60 mg/kg) and ranged from 73.8 mg/kg to 116 mg/kg in the 1-foot depth and 66.9 mg/kg to 89.2 mg/kg in the 5-foot depth. These ranges are slightly above the NAS baseline of 76.5 mg/kg and below the USGS baseline of 2,000 mg/kg and not considered significant.

Cobalt was detected in the 1-foot depth sample from SB13-03 at 20.3 mg/kg. The concentration was above the NAS baseline of 18.6 mg/kg.

Copper was detected above the MV-18 baseline (44 mg/kg) in three soil samples only at the 1-foot depth, and ranged from 46.5 mg/kg to 55.8 mg/kg. This range of copper is within the NAS baseline (56.7 mg/kg) and is not considered excessive.

Lead was detected above the NAS baseline of 28.3 mg/kg in four soil samples and ranged from 76.3 mg/kg to 462 mg/kg. The highest concentration was in the 1-foot depth sample from SB13-3. The data indicate that lead contamination is present in the drainage ditch at down to 5-foot depths.

Nickel was detected above the Hetch-Hetchy baseline (47 mg/kg) in all soil samples from Site 13. The levels ranged from 70.7 mg/kg to 92.2 mg/kg. Only one sample from SB13-03 at the 1-foot depth (92.2 mg/kg) was above the NAS baseline of 88.5 mg/kg.

Vanadium was detected (86.7 mg/kg) above the NAS baseline of 78.2 mg/kg from the 1-foot depth of SB13-03.

Zinc was detected above the NAS baseline (104.1 mg/kg) in five samples and ranged from 116 mg/kg to 198 mg/kg.

Summary

In summary, runoff of oil and grease appears to be accumulating in drainage ditches at Site 13. Most metals appear to be within the parameters established for soils or not significantly elevated above NAS baselines. However, lead concentrations are considerably higher than the established baseline and indicate contamination in ditch soils. Additional work will be required to determine the extent of contamination in the ditches.

17.0 ABANDONED TANKS 19, 20, 67, AND 68 - SITE 14

17.1 DESCRIPTION AND HISTORY

Tanks 19 and 20

Tanks 19 and 20 were located on the corner of Macon Road and the South Gate Exit (Figure 17.1-1). Both tanks have been removed.

Each tank had a capacity of 5,000 gallons and contained unleaded vehicle fuel. The area around the tank is heavily stained and after the tanks were removed, petroleum hydrocarbon contamination was discovered in the soil and ground water (ERM-West, May 1987).

Tanks 67 and 68

Tanks 67 and 68 are located on the southwest corner of Wescoat Road and Severyns Avenue, between the Dry Cleaners (Building 88) and the NEX Gas Station (Figure 17.1-2). The age, contents, volume, and use of the tanks is unknown. Tank 67 was recently removed and Tank 68 was closed in place.

Soil boring and well data from a previous investigation indicate that these tanks may have been a source of TCE, cis-1,2-DCE, and 1,1-DCE in ground water. However, because of the proximity of the tanks to the Dry Cleaner's Sump (Site 18), the available data are not conclusive. The source/plume relationships are further complicated by the regional plume.

17.2 FIELD INVESTIGATION

The investigation activities for Site 14 included:

- Installation of monitoring wells
- Collection of shallow borehole soil samples
- Ground water and soil analysis
- Installation of geophysical borings
- Water level measurements.

17.2.1 Ground Water Monitoring Wells

The following wells were installed at Site 14 (Tanks 19 and 20) during Phase I of the RI:

- W14-01(A2)
- W14-02(A1)
- W14-03(A1)
- W14-04(A1)
- W14-05(A2)
- W14-06(A2).

W14-01(A2) and W14-02(A1) were installed downgradient (north) of the Tank 19 and 20 site. W14-03(A1) and W14-05(A2) were installed on the west flank of the tanks and W14-04(A1) and W14-06(A2) were installed on the east flank of the tanks. All wells were installed to monitor the lateral and vertical extent of contamination. Well construction details are presented in Appendix I of the December 1988 Quarterly Report (IT, 1988e). A summary of well construction details is also given in Table 2.3-2.

No ground water monitoring wells were installed to monitor the Tank 67 and 68 site. Wells installed before the RI by a previous contractor were used to provide information about ground water contamination. The investigation conducted during the recent removal/closure of these tanks will indicate the need for any additional monitoring.

17.2.2 Soil Samples

Soil samples from the monitoring well borings and shallow soils borings at Tanks 19 and 20 were collected and analyzed from the vadose zone at 1-, 3-, and 5-foot depths. A total of 30 soils samples were analyzed for VOCs, metals, PCBs, BNAs, and TPHC. Complete analytical results were included in the August 1989 Quarterly Report (IT, 1989c). A summary compilation is presented in Appendix C of this report. The locations of monitoring well borings and soil sample borings for tanks 19 and 20. are shown in Figure 17.1-1.

17.2.4 Ground Water Samples

Six rounds of ground water samples were collected from the RI wells and four rounds were collected from MEW wells 72(A1) and 74(A1). Samples from the

Phase I wells were analyzed for VOCs, PCBs, specific conductivity, pH, major anions, TDS, metals, BNAs, and TPHC. Samples from the MEW wells were analyzed for VOCs, specific conductivity, pH, major anions, and TDS. Complete analytical results were presented in the August 1989 (IT, 1989c), November 1989 (IT, 1989d), and February 1990 (IT, 1989) Quarterly Reports. A summary compilation is presented in Appendix D of this report.

Water Level Measurements

Water level measurements were collected monthly over a period of one year, extending from November 1988 to October 1989. Data from these measurements have been compiled into hydrographs and are included in Appendix A of this report.

17.3 HYDROGEOLOGY

17.3.1 Site Geology

The geology of Site 14, Tanks 19 and 20, and Tanks 67 and 68, is similar to the adjacent Site 9. An expanded discussion of this area is provided in Section 12.

17.3.2 Hydrology

Site 14 tanks are on the west side of NAS Moffett Field and, because of their limited areal extent, no surface water features are present. See Section 12 (Site 9) for a detailed description of the hydrology in the area of the former tank locations.

17.4 NATURE AND EXTENT OF CONTAMINATION

17.4.1 Sources

Sources at Site 14 in the southern area include the removed Tanks 19 and 20 which were unleaded gasoline storage tanks, an upgradient fuel storage tank (Tank 21), and a regional chlorinated VOC plume in the A1 and A2 subaquifers.

Sources at the northern Site 14 include Tanks 67 and 68, (contents unknown), the nearby Dry Cleaner's Sump (Sump 66), a regional chlorinated VOC plume in the A aquifer, and nearby fuel storage tanks at the NEX station.

17.4.2 Review of Chemical Analyses

Soils and Sediments - Tanks 19 and 20

A total of 30 soil samples were collected and analyzed for VOCs, BNAs, TPHC, and metals. Samples were collected from the 1-, 3-, 4.5-, 5-, 6-, and 6.5-foot depths. A statistical evaluation of the analytical results is presented in Tables 17.4-1 through 17.4-4. The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each sample was associated with method blank contamination. Methylene chloride was found in all samples and acetone was found in 20 samples. 2-butanone was found in one sample at 16 ug/kg. Toluene was found in two samples and ranged from 7 ug/kg to 9 ug/kg. Both the 2-butanone and toluene are also suspected as possible laboratory contaminants because of associated method blank contamination in samples with 2-butanone and toluene below quantitation limits.

1,1,1-Trichloroethane was found in W14-04(A1) at the 3-foot depth at 8 ug/kg. Bis(2-ethylhexyl) phthalate was found in SB14-02 at the 5-foot depth at 530 ug/kg.

These data indicate that any organic soil contamination is limited in extent in the shallow soils surrounding the tanks.

A statistical summary of metals and nonmetals detected in soils from Site 14 is presented in Tables 17.4-1 through 17.4-4. The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed in Table 3.2-1. A review of soils data shows that several inorganics are present above the established baselines. Elements that exceed the baselines are: arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, nickel, selenium, vanadium, and zinc. Common inorganic constituents within the soils (aluminum, calcium, sodium, potassium, and magnesium) will not be discussed.

Arsenic was detected above the Hetch-Hetchy baseline of 6.3 mg/kg in six samples. SB14-03 contained 269 mg/kg at the 3-foot depth and 191 mg/kg at the

5-foot depth. W14-02(A1) contained 241 mg/kg at the 3-foot depth and 43.3 mg/kg at the 5-foot depth. W14-05(A2) contained 13.0 mg/kg at the 5-foot depth. W14-05(A2) contained 13.0 mg/kg at the 5-foot depth. W14-04(A1) contained 28.5 at the 6.5-foot depth. No reason for the elevated arsenic is known.

Barium was detected above the NAS baseline of 220.4 mg/kg in ten soil samples that ranged from 227 mg/kg to 646 mg/kg. Barium was not detected above the baseline in samples from the 1-foot depth. Only one sample, from the 3-foot depth of W14-03(A1), which contained 299 mg/kg was above the baseline. All other samples above the baseline were from the 5-, 6-, or 6.5-foot depth.

Beryllium was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in 12 samples that ranged from 2.0 mg/kg to 5.6 mg/kg. Five samples were also slightly above the NAS baseline (3.7 mg/kg).

Cadmium was detected above the MV-18 baseline of 3 mg/kg in one sample. W14-02(A1) contained 5.0 mg/kg at the 3-foot depth. This range is also above the NAS baseline of 3.5, but below the USGS baseline of 10 mg/kg.

Chromium was detected in 15 soil samples above the Hetch-Hetchy baseline (60 mg/kg) and ranged from 64.0 mg/kg to 74.3 mg/kg except for W14-04(A1), which had 92.5 mg/kg at the 1-foot depth. All except this sample were below the NAS baseline of 76.5 mg/kg, and all were below the USGS baseline of 2,000 mg/kg.

Cobalt was detected above the NAS baseline of 18.6 mg/kg in 14 samples which ranged from 19.7 mg/kg to 46.0 mg/kg. These levels are below the USGS baseline of 70 mg/kg.

Copper was detected above MV-18 baseline (44 mg/kg) in 17 soil samples which ranged from 44.7 mg/kg to 133 mg/kg. This range is within or above the NAS baseline (56.7 mg/kg) and below the USGS baseline of 700 mg/kg.

Iron was detected above the NAS baseline of 38,347 mg/kg in 13 samples which ranged from 39,000 mg/kg to 79,400 mg/kg. Although these concentrations of iron are above the NAS baseline, they are not above the USGS baseline of

100,000 mg/kg.

Manganese was detected above the NAS baseline (721 mg/kg) in 13 samples which ranged from 792 mg/kg to 2,360 mg/kg. The concentration of manganese varies with depth. The 5- to 6.5-foot depth had 2,100 mg/kg to 2,360 mg/kg and the 1- and 3-foot depths had 792 mg/kg to 1,580 mg/kg. These levels are all below the USGS baseline of 7,000 mg/kg.

Nickel was detected above the Hetch-Hetchy baseline (47 mg/kg) in 25 soil samples from Site 14. The levels above baseline ranged from 50.1 mg/kg to 117 mg/kg. Two samples from one well boring were above the NAS baseline of 88.5 mg/kg; W14-03(A1) at the 3-foot depth had 111 mg/kg and 117 mg/kg was detected at the 6-foot depth.

Selenium was detected above the USGS baseline of 0.5 mg/kg in three samples. W14-02(A1) contained 1.7 mg/kg at the 1-foot depth and 7.2 mg/kg at the 5-foot depth. W14-04(A1) contained 1.5 mg/kg at the 5-foot depth. No source has been identified for selenium, however, insufficient data are available to determine a baseline concentration for NAS Moffett Field.

Silver was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in six samples which ranged from 2.6 mg/kg to 7.1 mg/kg. No silver was found at the 5-foot depth or >5-foot depth. Two samples were slightly above the NAS baseline of 5.0 mg/kg; W14-02(A1) at the 1-foot depth had 7.1 mg/kg and W14-01(A2) at the 1-foot depth had 5.4 mg/kg.

Vanadium was detected above the NAS baseline of 78.2 mg/kg in 12 soil samples which ranged from 79.2 mg/kg to 198 mg/kg. Although vanadium is above the NAS baseline, it is below the USGS baseline of 500 mg/kg.

Zinc was detected above the NAS baseline of 104.1 mg/kg in four samples which ranged from 109 mg/kg in W14-01(A2) at the 1-foot depth to 160 mg/kg in W14-02(A1) at the 5-foot depth. Two samples were reported above the Hetch-Hetchy and MV-18 baselines (110 mg/kg). All detections were below the USGS baseline of 3,500 mg/kg.

Many metal to nonmetal elements were found above baselines, but most were not significantly elevated above baselines. Three elements; arsenic, barium, and selenium, were found at levels significantly above baselines. The source of these element concentrations is not known.

Soil Gas

Field testing of shallow soil for total ionizable compounds was conducted at 10 sample stations approximately 200 to 300 feet north of Tanks 19 and 20, to determine if a contamination plume extended to this area. Concentrations detected ranged from 0.1 to 4.2 ppm. Sample station locations and detected concentrations are shown in Figure 17.4-1.

Six samples were collected from selected sample stations for analysis by GC. 1,1-DCA was detected in three samples at concentrations of 130 ppb, 154 ppb, and 155 ppb. GC analytical results are shown in Table 17.4-5.

Toluene was detected in two of the samples collected for GC analysis at concentrations of 24 ppb and 32 ppb.

The concentrations and distributions of organic compounds found in soil gas from these locations are not indicative of a soil gas plume extending to the survey area from former fuel Tanks 19 and 20.

Ground Water - Tanks 19 and 20

A total of eight wells were sampled in the Phase I investigation. Samples from the six newly installed wells were analyzed for BNAs, VOCs, PCBs, metals, and nonmetals. Samples from the MEW wells were analyzed only for VOCs and major ions. Samples were taken from:

- W14-01(A2)
- W14-02(A1)
- W14-03(A1)
- W14-04(A1)
- W14-05(A2)
- W14-06(A2)
- 72(A1) MEW
- 74(A1) MEW

A statistical summary of detected chemicals in water is provided in Table

17.4-6.

Acetone and methylene chloride, common laboratory contaminants, were frequently detected compounds. In most cases, the detections were associated with method blank contamination. These compounds were detected in sample analyses for five of the six wells. W14-02(A1) contained acetone that ranged from 1,700 µg/l to 4,400 µg/l.

Elevated levels of organics which were found include:

Compound	Concentration (ug/l)				
	72(A1)	74(A1)	W14-04(A1)	W14-02(A1)	W14-05(A2)
1,1,1-trichloroethane	5	13 - 22		-	10 - 17
1,1-dichloroethane	7 - 10	7 - 11		-	5 - 7
1,2-dichloroethane				160	-
1,2-dichloroethenes (total)		20 - 25		-	19 - 26
1,1-dichloroethylene		8 - 16		-	15 - 18
Trichloroethene	19 - 140	54 - 100	10	-	130 - 170
Tetrachloroethene	8 - 12				
2-methylnaphthalene				10 - 25	-
Naphthalene				41 - 110	-
Total xylenes				410 - 1,100	-
4-methylphenol				20 - 24	-
Benzene				2,600 - 2,800	-
Ethyl benzene				330 - 440	-
Toluene				520 - 910	-
Acetone				1,700 - 4,400	

No contaminants were noted in W14-03(A1).

TPHC was detected in W14-01(A2) at 3.9 mg/l and in W14-02(A1) ranging from 3.8 mg/l to 18 mg/l.

From the distribution of contaminants, (fuels only in the A1 subaquifer and chlorinated VOCs in the A2 subaquifer), it appears that the source of chlorinated volatile compounds is the MEW plume. Contaminants originating from fuels appear to be from Tanks 19 and 20.

Several metals and nonmetals were consistently above the quantitation limit. A statistical summary of these elements is presented in Table 17.4-6. Naturally occurring inorganic constituents in the soils (aluminum, calcium,

sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has contributed to the natural degradation of the water quality. The naturally occurring elements and compounds will not be discussed in this text.

Metals found in the ground water include: arsenic, barium, beryllium, iron, manganese, selenium, and silver.

Several elements were detected consistently in one to three wells at Site 14. Arsenic was found in six samples from W14-02(A1) which ranged from 23 µg/l to 43 µg/l. Barium was found in four samples; one from W14-04(A1) at 298 µg/l and three from W14-02(A1) ranging from 235 µg/l to 587 µg/l. Iron was found in 29 samples from five wells. In the A1 wells, iron concentrations ranged from 243 µg/l to 13,400 µg/l and in the A2 wells from 138 µg/l to 565 µg/l. Manganese was found in 32 samples and ranged from 23.7 µg/l to 2,240 µg/l. Selenium was found consistently in two wells, and one time in a third well and ranged from 5.2 µg/l to 7.5 µg/l.

Beryllium was found in one sample from W14-04(A1) at 3 µg/l. Silver was found in one sample from W14-04(A1) at 14.8 µg/l.

Of those metals which were detected consistently, arsenic, iron, and manganese were above the California DWR range (Table 3.5.1). However, levels of iron and manganese are typical of the station ground water. The source of the elevated levels of arsenic in the A1 aquifer wells is unknown, though it was also high in soil samples.

Summary

Elevated levels of inorganics occur in soil and ground water near the former locations of Tanks 19 and 20; the source of these inorganics is unclear. Chlorinated organics occur in the A2 aquifer to the south and west of the former locations of Tanks 19 and 20, presumably from the MEW plume. Organics from fuel sources are present in the A1 aquifer near the Tanks 19 and 20 location, presumably from the tanks.

Tank 67 and 68

Field work associated with this study has not started at these tank sites.
Tank 67 was recently removed and Tank 68 was closed in place by the Navy.

18.0 SUMPS AND OIL/WATER SEPARATORS - SITE 15

18.1 DESCRIPTION AND HISTORY

The Navy has installed numerous sumps and oil/water and separators throughout the station. The sumps were generally for temporary storage of waste that is scheduled for removal and disposal either on- or off- the property.

Separators are for removing sediment and/or oil from waste streams prior to discharge into the sanitary sewer system. It is not known whether contents from these sumps and oil/water separators have leaked into adjacent soils.

Information available for the sumps and separators is general and is summarized as follows from ERM-West (1986a and 1986b):

Number	Description
25	A 2,000-gallon oil/water separator
42	A vapor recovery condensation sump at the NEX Auto Service Center
54	Oil/water separator
58	Oil/water separator
59, 62, 63 and 64	Sumps/separators
65	A sump that receives neutralized battery acid and wastewater from the battery locker. Subsequent disposal is into the sanitary sewer system.

Locations of these facilities are shown on Figure 18.1-1.

18.2 FIELD INVESTIGATION

No investigation was performed at Site 15 during Phase I. Phase II activities will include:

- Sampling and analysis of liquid waste
- Collection of shallow borehole soil samples

- Soil chemical analysis.

18.3 HYDROGEOLOGY

For specific information relative to the hydrogeology at the location of each sump and oil/water separator, refer to the following sections in this report:

<u>Sump or Separator Number</u>	<u>Section Number</u>
25, 42, 62, and 58	12 (Site 9)
54, 59, 63, and 65	10 (Site 7)
64	5 (Site 2)

18.4 NATURE AND EXTENT OF CONTAMINATION

Field work has not commenced.

19.0 PUBLIC WORKS STEAM CLEANING RACK, SUMP NO. 60 - SITE 16

19.1 Description and Site History

The Public Works Steam Cleaning Rack (Containment Facility No. 60) is located within the confines of the Public Works Vehicle Yard, which is situated between the South Gate and Girard Road (Figure 19.1-1).

The steam cleaning rack (wash rack) system consists of two catch basins which drain a concrete wash pad and drain to an underground oil/wash separator (Figure 19.1-2). The wash rack is no longer in use, and the age of the system, frequency of use, volume of wash water used, and type and amount of discharge are unknown. Effluent was reportedly discharged to a storm drain.

Currently, the ground water at this site is not being monitored. The MEW Companies have installed A aquifer wells 72(A1) and 64(A) about 600 feet upgradient of the wash rack system and a cluster of five downgradient wells [48B(1), 53B(2), 58B(3), 70B(3), and 74A] (Figure 19.1-1). Two underground containment facilities (Nos. 57 and 58) are located within 400 to 500 feet of the wash rack system. Former locations of Tanks 19 and 20, (now removed) are also within 400 feet of the wash rack system. These containments are fuel tanks and oil/water separators and are discussed in Section 17 (Site 14) and Section 18 (Site 15).

19.2 Field Investigation

No Phase I field activities were conducted at Site 16. Phase II investigation activities at Site 14 are to include:

- Sampling and analysis of liquid waste
- Collection of soil samples from shallow borings
- Cleaning and inspection of the oil/water separator and catch basins
- Removal of Sump No. 60 (scheduled for Fall 1990).

19.3 HYDROGEOLOGY

The local hydrogeology of Site 16 is typical of adjacent Site 9. An expanded discussion of local geology is provided in Section 12.

Surface Water

The site is covered with concrete and/or asphalt. The runoff flow drains to local catch basins and is diverted into the storm drainage system.

19.4 Nature and Extent of Contamination

No field work has been conducted at Site 16.

20.0 PUBLIC WORKS PAINT SHOP SUMP NUMBER 61 - SITE 17

20.1 DESCRIPTION AND HISTORY

The Public Works Paint Shop is located in Building 45, which is on the corner of Severyns Avenue and North Akron Road (Figure 20.1-1). The site has been active since the late 1930s (NEESA, 1984) and the building is still used as a paint shop. A concrete sump (61) is located on the north side of the building. The sump received wastes from the paint shop and from Hangar 1. Waste from the paint shop have included oil- and latex-based paints, thinners, toluene, and turpentine. The types of wastes received from Hangar 1 are unknown.

Sump 61 is no longer in use and will be removed as an interim remedial measure. Sump 62 located near Sump 61, is part of Site 15 and will be investigated in Phase II.

20.2 INVESTIGATION OBJECTIVES

No Phase I investigation activities were conducted at Site 17. Phase II investigation activities for Site 17 will include:

- Sampling and analysis of liquid waste from the sump
- Collection of shallow soil samples
- Soil chemical analysis.

20.3 HYDROGEOLOGY

Site 17 is within the boundaries of Site 9. A discussion on the local geology and hydrology is provided in Section 12 (Site 9).

20.4 NATURE AND EXTENT OF CONTAMINATION

Sump 61 has been identified as a suspected source of hydrocarbons and other chemicals in the soil and ground water. However, field work has not started at this site. The Navy has immediate plans to remove this sump.

21.0 DRY CLEANER'S SUMP NO. 66 - SITE 18

21.1 DESCRIPTION AND HISTORY

The Dry Cleaner's Sump (No. 66) is located on the north side of Building 88 just off Wescoat Road (Figure 21.1-1). In the Dry Cleaner's building, sinks and floor drains at the extractor/spotting station and floor drains near the dry cleaning machines flowed into Sump 66. The building and sump are surrounded by paved parking areas and streets. Wescoat Road on the north side of the sump is the southern boundary of Site 9. Tanks 67 and 68, recently removed/closed in place, are on the east side of the building and are part of Site 14. As a result of an earlier investigation of potential soil and ground water contamination near the sump and Tanks 67 and 68 (ERM-West, 1987), the Navy recently removed Sump 66.

21.2 FIELD INVESTIGATION

Phase I activities for the site were limited to activities performed as part of the Site 9 investigation near the Site 18 sump. These included:

- Conducting a soil gas survey
- Installing one A2-subaquifer well downgradient of the sump.

Data collected from these activities were used to plan the Phase II investigation in the part of Site 9 which is immediately downgradient of Site 18, Sump 66.

21.3 HYDROGEOLOGY

21.3.1 Site Geology

No new borings or wells were placed at Site 18 during the Phase I investigation. The site borders Site 9 and the geology is assumed to be consistent with that site. A detailed description of the Site 9 geology can be found in Section 12.3.1.

21.3.2 Hydrology

Surface Water - The site is covered by concrete and/or asphalt. Runoff flow is diverted to local catch basins and into the storm drainage system.

Vadose Zone and Ground Water - No new monitoring wells or borings were placed at Site 18. Site 9 monitoring wells W09-14(A2) and W09-15(B2) are about 200 and 600 feet downgradient of Site 18, respectively. GB-10 is also about 200 feet downgradient of Site 18. Data from the wells and boring provide some information on the vadose zone and ground water conditions near Site 18. In the two wells, ground water was first encountered at 21 feet bls in W09-14(A2) and at 20 feet bls in W09-15(B2). More detailed information on ground water conditions near Site 18 is presented in the Site 9 hydrology section (Section 12.3.2).

21.4 NATURE AND EXTENT OF CONTAMINANTS

21.4.1 Sources

Sump 66 was investigated by ERM-West (1987) as part of an investigation of potential soil and ground water contamination near Tanks 67 and 68. During the investigation, ERM-West drilled two borings (B-13 and B-14) near the sump, collected soil samples, and installed a monitoring well (ERM-4) in boring B-14. Field observations revealed cracks in the sump.

In Boring B-13, PCE was detected in soils (presumably below water table) in concentrations of up to 6,900 µg/kg at 12.0 to 12.5 feet bls. TCE was detected at concentrations of up to 910 µg/kg at 19.5 to 20 feet bls. In Boring B-14, PCE was detected in concentrations of up to 2,100 µg/kg at 19.5 to 20 feet bls and TCE was detected in concentrations of up to 710 µg/kg at 17.0 to 17.5 feet bls. Other solvents (including 1,1-DCA, 1,1-DCE, cis-1,2-DCE, dichlorotrifluoroethane (DCTFA), TCA, and Freon 113) were also detected but in smaller concentrations.

A ground water sample from ERM-4, which is screened from 15 feet to 20 feet bls, contained TCE (1,900 ppb), PCE (13,000 ppb), DCTFA (86 ppm), 1,1-DCA (150 ppb), 1,1-DCE (150 ppb), cis-1,2-DCE (1,600 ppb), TCA (16 ppb), and Freon 113 (10 ppb). A sample of the waste in Sump 66 contained 18,000 ppb of PCE.

The source of some of the chemicals in ground water in this area is unknown. There are a number of possible upgradient sources, including the MEW area and other tanks in the area (i.e., removed Tanks 67 and 68).

A number of upgradient wells have been installed by the MEW firms and ERM-West. Those in close proximity to Building 88 are MEW wells 66A, 81(A1), ERM-5 and ERM-6 (Figure 21.1-1).

Soil Gas

Field testing of shallow soil gas was conducted as part of the Site 9 investigation. Approximately 35 stations in the Site 18 area were field tested for total ionizable compounds. The range of concentrations were 0.2 ppm to 216.3 ppm. A soil gas transect map and a contour map of the soil gas concentrations are shown in Figures 12.4-1 and 12.4.2, respectively.

Samples for GC analysis were collected from 13 of the sample stations in the Site 18 area. Six of the ten target compounds were found in these samples. The results of the GC analysis are shown in Table 12.4-5.

1,1-DCA and 1,1,1-TCA were each detected one time in a sample from the south side of the dry cleaners. Concentrations were 17,900 ppb of 1,1-DCA and 12,500 ppb of 1,1,1-TCA.

1,1-DCE was detected in eight of the GC samples at concentrations ranging from 51.5 to 12,900 ppb. The samples were collected from stations scattered throughout the Site 18 area.

Cis-DCE was detected 11 times at concentrations ranging from 136 ppb to 97,300 ppb.

TCE was detected in all 13 GC samples collected from the Site 18 area. The range of concentrations was 36 ppb to 941,000 ppb. The latter was the highest concentration of TCE recorded from Site 9 samples by almost an order of magnitude. Its occurrence northeast of the dry cleaners indicates Site 18 as a possible source.

Toluene was detected in four GC samples from the west side of Site 18. Concentrations ranged from 18 ppb to 126 ppb.

Ground Water

No monitoring wells were installed or sampled in the Phase I investigation of Site 18. As noted earlier, Site 9 well W09-14(A2) is about 200 feet downgradient of Sump 66 and provides some information on ground water chemistry in the area. The detailed chemistry is described in Section 12.4.2. Significantly, this well contained high levels of TCE ranging from 160 to 36,000 ug/l. While PCE was the compound of highest concentration reported for the ERM-4 well immediately downgradient of the sump, this compound was not detected in W09-14(A2) (sample quantitation limit, 1,000 ug/l). The quantities of other VOCs in the W09-14(A2) well were estimated to be below the method detection limits.

In summary, monitoring data from Site 18 are limited. Previous investigative data and soil gas data from the Phase I investigation indicate that Sump 66 is a possible source of PCE and TCE. Site 9 data do not appear to indicate widespread contamination from this source in the A2 subaquifer. However, as the data are limited, additional work is required to determine the extent of contamination in the A1 and A2 subaquifers. The Phase II work planned in this area, and results of the investigation conducted during the recent sump removal, will provide information to determine if additional work is required.

22.0 LEAKING TANKS NOS. 2,14,43, AND 53 - SITE 19

22.1 DESCRIPTION AND HISTORY

Tanks 2 and 43 were located on the east side and northeast corner of Hangar 3, respectively (Figure 22.1-1). Tank 14 was located approximately 10 feet south of Building 158 (Figure 22.1-2). Tank 53 was located in the maintenance yard which surrounds Buildings 376 and 399 (Figure 22.1-3). All four tanks were removed by the Navy in June 1990.

Tank 2 was installed in 1979 and had a capacity of 2,000 gallons. It was used as a hazardous waste storage tank for wastes from the Power Plant Shop located in Hangar 3. Waste products included oils, hydraulic fluids, MEK, JP fuels, B&B cleaner, PD-680 solvent, toluene, and Stoddard solvent (ERM-West, 1986a).

Tank 43 was a 200-gallon hazardous waste collection and storage tank. Tank 43 collected rinse water from engine cleaning racks, drains, and sinks in Hangar 3. This tank contained waste oils, solvents, waste fuel, MEK, PD-680 solvent, paint waste, and battery acids. The tank was installed in 1979. (ERM-West, 1986a).

Tank 14 was a 1700-gallon unvaulted standby diesel tank for Building 158, the Line Shack. The tank was located in the lawn area ten feet south of Building 158 and approximately 400 feet east of the intersection of Cody and Macon Roads (Figure 22.1-2). Tank 14 was approximately 600 feet downgradient of MEW monitoring wells 49(B1), 54(B2), and 59(B3). On visual inspection, the tank appeared to have two ports for filling and one vapor-release valve. Tank 14 reportedly was emptied well before the Navy removed it.

Tank 53 was located approximately 120 feet southeast of the intersection of Patrol Road and Marriage Road (Figure 22.1-3). The tank was a 500-gallon unleaded gasoline tank for use at the golf course physical plant and was removed from service following discovery of a plumbing leak (ERM-West, 1987).

22.2 FIELD INVESTIGATION

The investigation activities for Site 19 were:

- Core and log a geophysical boring
- Install monitoring wells
- Install shallow soil borings
- Collect and analyze soil samples
- Analyze ground water and soil samples
- Perform aquifer tests
- Collect water level measurements.

22.2.1 Geophysical Borings

One geophysical boring, GB-29, was drilled, logged, and continuously cored at Site 19. The location of this boring is shown in Figure 22.1-1. The lithologic and geophysical logs are presented in Appendices I and J in the December 1988 Quarterly Report (IT, 1988e).

22.2.2 Ground Water Monitoring Wells and Soil Borings

The following wells were installed at Site 19 during Phase I of the RI:

- W19-01(A2)
- W19-02(A2)
- W19-03(A2)
- W19-04(A2)

Well W19-01(A2) was installed just north and downgradient of Tank 43 and well W19-02(A2) was located south and upgradient of Tank 43 (Figure 22.1-1). Wells W19-03(A2) and W19-04(A2) were installed about 400 feet downgradient of Tank 43 to monitor the lateral and vertical extent of contamination (Figure 22.1-1).

Three soil borings at Tank 2 (SB19-01, -02, and -03) and two soil borings at Tank 43 (SB19-04, and -05) were drilled around the tanks and their associated piping to collect vadose zone soil samples. The locations of the borings are shown in Figure 22.1-1.

22.2.3 Soil Samples

Soil samples from the monitoring well borings and shallow soils borings were collected and analyzed from the vadose zone at 1-, 3-, and 5-foot depths. A

total of 32 soils samples were analyzed for VOCs, metals, PCBs, BNAs, and TPHC. Complete analytical results are included in the August 1989 Quarterly Report (IT, 1989c). A summary compilation is presented in Appendix C of this report. The locations of monitoring well borings and soil sample borings are shown in Figure 22.1-1.

22.2.4 Ground Water Samples

Six rounds of ground water samples were collected in four quarters and analyzed for VOCs, PCBs, specific conductivity, pH, major anions, TDS, metals, BNAs, and TPHC. Preliminary analytical results are available in the August 1989 (IT, 1989c), November 1989 (IT, 1989d), and February 1990 (IT, 1990) Quarterly Reports. A summary compilation of significant observations is given in Appendix D of this report.

22.2.5 Aquifer Testing

An A aquifer pump test was conducted near Tank 43. Five wells were utilized for the test. The pumping test was conducted on well W19-01(A2). A 2-inch observation well was installed 20 feet from W19-01(A2) in the downgradient direction. The observation well was also in the A aquifer. The results of pumping W19-01(A2) was also observed in W19-02(A2), W07-21(A1), and W07-19(A1). The test provided information on the hydraulic properties of the A1 and A2 subaquifers.

22.2.6 Water Level Measurements

Water level measurements were collected monthly over a period of 1 year, extending from November 1988 to October 1989. Data from these measurements have been compiled into hydrographs and are included in Appendix A of this report.

22.3 HYDROGEOLOGY

22.3.1 Site Geology

The geology of Site 19, Tanks 2 and 43, is typical of the adjacent Site 7. An expanded discussion of this area is provided in Section 10. The geology of Site 19, Tank 14, is similar to the adjacent Site 9. An expanded discussion of this area is provided in Section 12. The geology of Site 19, Tank 53, is

typical of the adjacent Site 3. An expanded discussion of this area is provided in Section 6.

22.3.2 Hydrology

No surface water features are associated with any of the Site 19 tanks. See Section 6 (Site 3), Section 10 (Site 7), and Section 12 (Site 9) for detailed hydrologic descriptions of the various tank locations.

Ground Water

An aquifer test was conducted in Site 19 wells near the Tanks 2 and 43 locations. The results of this test indicate that the A1 and A2 subaquifers are interconnected in this area. Because of the heterogeneous nature of the subsurface materials, other test data were inconclusive.

22.4 NATURE AND EXTENT OF CONTAMINATION

22.4.1 Sources

Tanks 2, 14, 43, and 53 were sources of potential contamination to soils and ground water.

Wells were installed in the A1 subaquifer and the A2 subaquifer. Monitoring well W07-20(A2) was used to monitor Tank 43 (Figure 22.1-1), and well W03-23(A1) was used to monitor Tank 53 (Figure 22.1-3). There are no monitoring wells near Tank 14. Five soil borings were installed near Tanks 2 and 43 (SB19-01 to -05).

Ground water samples from monitoring wells installed by ESA indicate that Tank 43 is the primary source of a chemical plume in the A aquifer. The contamination consists principally of chlorinated hydrocarbon compounds (EMCON, 1983a and 1983b, and ESA, 1986b and 1986c).

Tank 43 is monitored by one A aquifer monitoring well W07-08(A2). There are two other wells clustered at the tank location [W19-2(A2), W19-1(A2)] and two wells about 400 feet downgradient [W19-3(A2) and W19-4(A2)].

Although not specifically constructed to monitor leakage from Tank 2, a down-

gradient A aquifer well [W07-20(A2)] is located in a position to monitor Tank 2. Well construction details are presented in the December 1988 Quarterly Report (IT, 1988e).

No monitoring wells were specifically installed to monitor Tanks 53 or 14 although several Site 3 wells provide monitoring data pertinent to Tank 53. Wells W03-03(A1) and W03-04(B2) are located approximately 25 feet south of Tank 53 and well W3-23(A1) is located 100 feet north of Tank 53.

Surface Water

There are no surface water features near Tanks 2, 14, or 43. Marriage Road Ditch is adjacent to the Tank 53 area and is discussed in Section 6.0 (Site 3).

22.4.2 Review of Chemical Analyses

Tanks 2 and 43 - Soils and Sediments

A total of 28 soil samples were collected and analyzed for VOCs, BNAs, PCBs, TPHC, and metals. Samples were collected from the 1-, 3-, and 5-foot depths except for Well W19-04(A2), which was sampled at 1-, 3-, 6-, and 13-foot depths. A statistical evaluation of the analytical results is presented on Tables 22.4-1 through 22.4-4. The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each detection was associated with method blank contamination. Methylene chloride was found in all samples and acetone was found in 11 samples.

Bis(2-ethylhexyl)phthalate was found in borings from two wells and ranged from 630 µg/kg at the 1-foot depth to 790 µg/kg at the 5-foot depth. SB19-03, however, contained 1,200 µg/kg at the 5-foot depth.

Trichloroethene was found in SB19-01, near Tank 2, at the 1-, 3-, and 5-foot depths. The concentrations were 58 µg/kg, 110 µg/kg, and 38 µg/kg. SB19-04, near Tank 43, contained trichloroethene and tetrachloroethene (13 µg/kg and 7 µg/kg, respectively) at the 5-foot depth. W19-01(A2), downgradient of Tank 43, contained 8 µg/kg of trichloroethene at the 3-foot depth.

TPHC was found in the 3-foot depth sample from W7-20(A2) at 110 mg/kg. The well boring is downgradient of Tank 2.

A summary of metals and nonmetals detected in soils from Site 19 is presented in Tables 22.4-1 through 22.4-4. The baseline ranges for inorganic constituents were discussed in Section 3.1 and are listed on Table 3.2-1. A review of soils data suggests that most inorganics are present below the established baseline. Elements that exceed the baseline are: arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver, vanadium, and zinc. Naturally occurring inorganic constituents within the soils (aluminum, calcium, sodium, potassium, and magnesium) will not be discussed.

Arsenic exceeded the Hetch-Hetchy baseline of 6.3 mg/kg in a single sample at 7.8 mg/kg. That measurement, from a 3-foot sample at W19-03(A2), is below the USGS, MV-18, and station baselines.

Barium was detected slightly above the NAS baseline of 220.4 mg/kg in four soil samples. Barium was found in one 1-foot sample from SB19-01 at 252 mg/kg, once at the 3-foot depth from W19-04(A2) at 276 mg/kg, and twice at the 5-foot depth in SB19-05 (270 mg/kg) and W19-01(A2) (270 mg/kg). These concentrations are not significantly greater than the baseline.

Beryllium was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in 18 samples (six each at 1-, 3-, and 5-foot depths) and ranged from 1.2 mg/kg to 3.5 mg/kg. This range is below the NAS baseline (3.7) mg/kg.

Cadmium was detected above the NAS baseline of 3.5 mg/kg in two samples. W19-04(A2) contained 9.4 mg/kg at the 1-foot depth, and W19-03(A2) contained 4.8 mg/kg at the 3-foot depth. This range is below the USGS baseline of 10 mg/kg.

Chromium was detected in 16 soil samples above the Hetch-Hetchy baseline (60 mg/kg) and ranged from 62.7 mg/kg to 88.2 mg/kg. This range is within or slightly above the NAS baseline of 76.5 mg/kg and below the USGS baseline of 2,000 mg/kg.

Cobalt was detected above the NAS baseline of 18.6 mg/kg in three samples which ranged from 20.1 mg/kg to 21.6 mg/kg. This level is slightly above the NAS baseline and below the USGS baseline of 70 mg/kg.

Copper was detected above MV-18 baseline (44 mg/kg) in 10 soil samples which ranged from 47 mg/kg to 98.9 mg/kg. The range of copper is within or slightly above the NAS baseline (56.7 mg/kg) and below the USGS baseline of 700 mg/kg.

Iron was detected above the NAS baseline of 38,347 mg/kg in four samples which ranged from 41,000 mg/kg to 67,600 mg/kg. The levels of iron are not above the USGS baseline of 100,000 mg/kg.

Lead was detected above the NAS baseline of 28.3 mg/kg in two samples from SB19-01 and ranged from 70 mg/kg to 75.8 mg/kg. These levels are above the Hetch-Hetchy (48 mg/kg) and MV-18 (54 mg/kg) baselines, but below the USGS baseline of 700 mg/kg.

Manganese was detected above the NAS baseline (721 mg/kg) at the 5-foot depth from W19-01(A2) at 1,860 mg/kg and at the 1-foot depth in SB19-01 at 728 mg/kg. These levels are above the NAS baseline but below the USGS baseline of 7,000 mg/kg and are not considered excessive.

Mercury was detected at the NAS baseline of 0.5 mg/kg in one sample at the 1-foot depth from W19-04(A2). This value is below the USGS baseline of 5.1 mg/kg and is not considered excessive.

Nickel was detected above Hetch-Hetchy baseline (47 mg/kg) in 24 soil samples from Site 19. The levels ranged from 47.6 mg/kg to 89.2 mg/kg except for W19-04(A2) which contained 203 mg/kg at the 1-foot depth. Most samples (22) were below the NAS baseline of 88.5 mg/kg. The source for the single high concentration is not known.

Silver was detected above the Hetch-Hetchy baseline of 0.8 mg/kg in three samples from W19-04(A2). Levels were 7.7 mg/kg at the 1-foot depth, 4.3 mg/kg at the 3-foot depth, and 3.9 mg/kg at the 6-foot depth. All samples were

within or slightly above the NAS baseline of 5.0 mg/kg.

Vanadium was detected above the NAS baseline of 78.2 mg/kg in six soil samples which ranged from 83.8 mg/kg to 169 mg/kg. Although vanadium is above the NAS baseline, it is below the USGS baseline of 500 mg/kg.

Zinc was detected above the NAS baseline of 104.1 mg/kg in two samples. Both samples were reported at 122 mg/kg which is slightly above the NAS, Hetch-Hetchy (110 mg/kg), and MV-18 baselines (110 mg/kg), but below the USGS baseline of 3,500 mg/kg.

Inorganic analysis of soil samples showed several constituents above baselines, though, most were elevated only to levels which are considered to be within the range of natural variation of soil composition. However, concentrations of lead in two soil samples from a boring adjacent to Tank 2 (70 mg/kg and 75.8 mg/kg) were elevated significantly above the NAS baseline. Nickel was found at significantly elevated concentrations in one 1-foot sample from a boring about 400 feet north of Tank 43. The source of the nickel is not known. Analysis of soils from the well boring downgradient of Tank 53 showed some metals above the low baselines, but none more than slightly above NAS baseline.

Tanks 2 and 43 - Ground Water

A total of four wells were sampled and analyzed for BNAs, VOCs, PCBs, metals, and nonmetals. Samples were taken from:

- W19-01(A2)
- W19-02(A2)
- W19-03(A2)
- W19-04(A2).

A summary of detected chemicals in water is provided in Table 22.4-5.

The most frequently detected compounds were the common laboratory contaminants acetone and methylene chloride. In most cases, each detection was associated with method blank contamination. These compounds were detected in samples from three of the four wells that were sampled.

Three wells contained elevated levels of organics which include:

Compound	Concentration (ug/l)			
	W19-01(A2)	W19-02(A2)	W19-03(A2)	W19-04(A2)
1,1,1-trichloroethane	6 to 9	5		5 to 9
1,1-dichloroethane	5 to 6			5 to 9
1,2-dichloroethenes (total)	10 to 17	11		
1,1-dichloroethylene				5 to 7
Carbon tetrachloride	8 to 17	6		
Chloroform	6 to 10		6	
Trichloroethene	19 to 25	17		
Toluene	10		8-20	
Benzene	38			

The probable source of these VOCs is from Tank 43. Continued work is planned to delineate the source of this organic contamination in the ground water.

Several metals and nonmetals were consistently above the quantitation limit. These elements and compounds are presented on Table 22.4-5. Naturally occurring inorganic constituents in the soils (aluminum, calcium, sodium, potassium, and magnesium) are present in high quantities in the ground water. Sea water intrusion in the area has contributed to the natural degradation of the water quality. The naturally occurring elements and compounds will not be discussed in this text.

Metals found in the ground water include; cadmium, iron, manganese, and zinc. Cadmium was found in one sample from W19-01(A2) at 13.5 ug/l. Iron was found in 13 samples and ranged from 108 ug/l to 330 ug/l. Manganese was found in 22 samples and ranged from 24.4 ug/l to 657 ug/l. Zinc was found in one sample at 71.7 ug/l. The iron and manganese levels found are typical of ground water at the station. The single occurrences of cadmium and zinc are not considered indicative of ground water contamination.

Summary

Ground water contamination near Tank 43 has occurred and consists primarily of chlorinated organics which are also present in shallow soils near the site. Chlorinated organics are found in shallow soils near Tank 2, although none were found in ground water from the nearest monitoring well, W7-20(A2). Investigation

of Tanks 14 or 53 has occurred as part of tank removal operations which were recently conducted.

23.0 CHEMICAL BEHAVIOR AND PERSISTENCE

The fate of chemicals in the environment depends on a variety of chemical, physical and biological processes. This section describes some of the processes that may occur for various compounds at NAS Moffett Field. The major processes at work in the natural environment include hydrolysis, volatilization, sorption, oxidation/reduction and biodegradation. Of these processes, volatilization and sorption appear to predominate for the classes of compounds of interest at NAS Moffett Field. Throughout the course of this report an effort has been made to identify the presence of potentially hazardous chemicals in the soil, sediments, surface water and ground water at NAS Moffett Field. At this stage of the investigation the focus has been on determining which types of chemicals may have an adverse impact on the public health and environment. These chemicals can be divided into two broad categories: metals and organics. The latter category appears at this time to be more significant. Organics can be further divided into chlorinated aliphatics, petroleum derived aromatics and polychlorinated biphenols (PCBs). The inorganic chemicals of interest include lead and silver.

During Phase II of the RI, transport will be performed. A basic understanding of how these chemicals behave or partition in soil and water is critical to the development of various model input parameters. The following discussion attempts to describe the behavior and persistence of target compounds. Examples will be used to discuss typical chemical fate processes that may occur in the NAS Moffett Field environment.

23.1 ORGANICS

Primary sources of organics at the site originate from on-site and off-site derived chlorinated solvents leaking from sumps and tanks or from spills. These hydrocarbon solvents are comprised of halogenated aliphatic or linear bonded structures, and a specific ring type structure called an aromatic. Chlorinated aromatics such as PCBs tend to be among the most environmentally persistent chemicals.

The transport and fate of many of the halogenated aliphatic hydrocarbons detected in the surface and near surface environment at NAS Moffett Field are

dominated by volatilization. Recent studies have demonstrated that biodegradation occurs for some compounds under both aerobic and anaerobic conditions. Chemicals in this class include trichloroethene (TCE), tetrachloroethene (PCE), and 1,1-dichloroethane. Trichloroethene is a leading index chemical for contamination at the site, particularly on the west side of the facility. Sorption processes, particularly on suspended natural organic polymers or humic material may also affect the mobility of organic compounds in the near surface environment.

The mobility of organic compounds within the saturated zone is affected by chemical processes that are in part dependent on their volatility, the octanol-water partition coefficient (K_{ow}), the water solubility, and the concentration. In general, the more water insoluble an organic compound is, the more hydrophobic it is and the more likely it is to be adsorbed on a sediment or organic surface. These compounds also have a tendency toward self-association in a polar medium such as water. Hydrophobic compounds tend to have higher K_{ows} and a greater affinity to organic matter contained within the sediment matrix. Table 23.1-1 contains physical and chemical characteristics of various organic compounds detected in site ground water. Compounds such as acetone, benzene, and the chlorinated aliphatic hydrocarbons with high aqueous solubilities also have relatively low K_{ows} . When present in the ground water at low concentrations, migration of these compounds tends to be more rapid than compounds such as phthalates, PCBs, or large aromatic compounds such as polycyclic aromatic hydrocarbons (PAH) which have low solubilities and high K_{ows} .

For low contaminant concentrations, the ratio of average ground water velocity to the velocity of the chemical constituents is represented by the retardation factor (R_f). The retardation factor is equal to unity when both ground water and the chemical constituents travel with the same average velocity. As the retardation factor increases, the rate of migration of the chemical decreases. The retardation factor for organic material is a function of the octanol-water partition coefficient, the fraction of organic carbon present in the medium, the porous medium porosity, and the bulk density. The following equation defines the retardation factor (Freeze and Cherry, 1979).

$$R_f = 1 + \frac{\rho}{n} K_d$$

where

R_f = retardation factor
 ρ = bulk density of the porous media
 n = porosity and
 K_d = distribution coefficient.

The relationship between K_d and K_{ow} is as follows (Karickhoff, et al., 1979):

$$K_d = K_{oc} \times \text{fraction of organic carbon}$$

where

K_{oc} = organic carbon partition coefficient.

From the relationship

$$\log K_{oc} = 1.00 \log K_{ow} - 0.21 \quad (\text{Karickhoff et al., 1979}),$$

the organic carbon partition coefficient (K_{oc}) may be calculated.

Even compounds with relatively low K_{ows} will, if the organic carbon content of the aquifer matrix is high, exhibit some attenuation within the ground water system. In the case of the fine-grained sediments where organic matter is high, such as the bay muds, significant retardation of many organic compounds would be expected to occur.

As an example, the $\log K_{ow}$ for trichloroethene (TCE) is 2.29 (Neely et al., 1974) and from the Karickhoff relationship, $\log K_{oc}$ is 2.08. Assuming a conservative average organic matter content of 3 percent in the younger bay muds (Qybm) the calculated K_d is 3.61.

Calculation of the retardation factor requires a knowledge of the aquifer parameters: porosity, and bulk density. Using an average porosity of 0.4 and a bulk density of 1.6 grams per cubic centimeter (Freeze and Cherry, 1979), the retardation factor may be calculated as follows:

$$R_f = 1 + \frac{1.6}{0.4} K_d$$

The calculated retardation factor for TCE in the younger bay mud aquifer at Moffett using these assumptions is thus 15.4.

In surface waters and surface soils the primary transport process for TCE would be volatilization. Because of its high vapor pressure it will tend to volatilize rapidly. In the atmosphere hydroxyl radicals attack the double bond, resulting in the ultimate formation of HCl, CO, and CO₂ with a half life of less than 1 day (EPA, 1975a).

Persistence of TCE in shallow ground water near the saturated/unsaturated zone interface is several orders of magnitude longer due to the significantly reduced air/water interface available. A study by Jensen and Rosenberg (1975) indicated that the rate of volatilization of TCE proceeds more rapidly than photolysis, hydrolysis, or oxidation.

At higher concentrations, the mobility of organic contaminants is less affected by sorption processes than by their density, viscosity, and hydrophobicity. At high contaminant concentrations, the limited sites on sediment and suspended humic materials are filled. Hydrophobic compounds will tend to form weak chemical bonds and move as a phase at velocities less than the average ground water velocity. If the density of the phase is greater than water, there will be a tendency for the organic mass to migrate downward into the aquifer. In the literature these have been referred to as dense non-aqueous phase liquids (DNAPL).

In addition to volatilization and sorption, other chemical processes may occur under certain conditions to alter the composition of various organic compounds. Some of the more important processes include:

- Hydrolysis
- Oxidation
- Reduction
- Hydration.

Under favorable conditions and kinetics, PCE has been reported by EPA (1975b) to undergo hydrolysis in the presence of oxygen to form trichloroacetic acid and hydrochloric acid. Cooper et al., (1987) reported the hydrolysis of

1,1,2,2-tetrachloroethane to TCE in the presence of phosphate and have reported good agreement with other research previously performed on this compound. Parsons et al., (1984) have reported the presence of cis- and trans-1,2-dichloroethene as degradation products from a TCE spill. The abiotic transformation of TCA has been reported by Vogel and McCarty (1985) under methanogenic conditions. The results of laboratory experiments, particularly measured rate constants, are heavily dependent on laboratory conditions. However they do indicate that such chemical transformations are thermodynamically and kinetically possible and should not be overlooked in the analysis of contaminant fate.

Biological processes may also alter the composition of various compounds into more or less toxic daughter products. Nelson et al., (1987) reported the biodegradation of TCE in the presence of phenol, toluene, 2-methylphenol, or 4-methylphenol under aerobic conditions. The resulting products were CO₂ and HCl. Other researchers (Vogel and McCarty, 1985; Kleopfer et al., 1985) have reported the biotransformation of this same compound under anaerobic conditions, with vinyl chloride among the resulting metabolites.

23.2 INORGANICS

Several inorganic compounds have been detected above ambient levels at various sites under investigation. Lead and silver appear to be two of the more significant metals from an environmental impact perspective. The proximity of NAS Moffett Field to a salt water bay has produced soils and ground water with locally high concentrations of inorganics such as sodium, calcium and magnesium. Discussion is limited here to the behavior of metals in general within the environment, and specifically lead. As with the organics, the behavior and persistence of relevant inorganics will be studied in detail during the course of the RI.

Heavy metals added to soils and ground water react with soil and aquifer components in a variety of ways. These reactions can generally be classified as ion exchange, adsorption, precipitation, and complexation. The reaction mechanisms and rates, both in soils and the water column, are dependent upon the type and amount of organic matter, clay, and hydrous oxides present in the soil. Additional factors are the pH, exchangeable cations, oxidation-

reduction potential (Eh), and the composition and concentration of soil water and ground water. At this time only a limited amount of data have been collected from San Francisco Bay soils with regard to the above parameters. Physical properties of soil collected in and around NAS Moffett Field are discussed in section 3.0 of this report.

Metal ions may be bound to soil particulates by a combination of forces ranging from electrostatic to covalent. Layer silicates or clay minerals such as smectite (e.g. montmorillonite), illite, and kaolinite tend to bind soluble species by ion exchange reactions due to electrostatic attractions. Ion exchange tends to be reversible but highly dependent on the type of clay mineral present, the composition of ions occupying exchange sites, the pH, and the composition of the ground water.

Sorption of metals is highly dependent upon the major elemental composition of the ground water. Metals ions form complexes with dissolved ligands such as chloride, carbonate, sulfate, and hydroxides that will change both their size and charge and thus affect their mobility. For example, sorption of copper in the presence of phosphate, sulfate, or humic acids is enhanced due to the formation of specific chemical bonds between the complex and the sorbent phase (Huang et al., 1977; Sanchez and Lee, 1973; Ramamoorthy and Rust, 1978). Copper complexation with the chloride ligand appears to suppress sorption (EPA, 1979). The extent of complex formation is dependent on the overall chemical composition of the aqueous system and is governed by thermodynamic equilibrium equations. Geochemical computer programs have been developed that calculate the thermodynamic concentrations of complexes, as well as determine the solubilities of various minerals in the ground water system. Programs such as WATEQ (Truesdell and Jones, 1974) PHREEQE (Parkhurst et al., 1980) and MINTEQ (Felmy et al., 1984) are well documented and have been used extensively as aids in predicting the chemical behavior of solutes in the ground water system.

Not only does the presence of various ligands affect the sorption of a metal, but the type of surface will also determine the extent of sorption. Clay minerals have different affinities for the adsorption of charged species due to geometric and chemical factors. This affinity is expressed as the cation

exchange capacity (CEC) and it relates to the molecular structure and chemical composition of the mineral lattice and the particle size distribution of the sample. Kaolinite minerals have lower exchange capacities than do illites, that in turn are lower than smectites under similar conditions. In the bay environment of NAS Moffett the types of clay minerals expected to be present would reflect the weathered source area and thus be dominated by illite and kaolinite with minor montmorillonite and chlorite.

Hydrous metal oxides such as manganese and iron hydroxides have the ability to attenuate metals by both adsorption and coprecipitation reactions. These minerals are ubiquitous in non-reducing environments and occur not only as discrete oxide grains, but also as coatings on silicate minerals and weathering products in rock fragments. These phases tend to have extremely high cation exchange capacities and their importance in concentrating heavy metals in the environment has been well documented (Murray, 1975; Suarez and Langmuir, 1976; Jenne, 1977; Means et al., 1978). Silver is effectively sorbed by hydrous manganese hydroxides, and to a lesser degree, by iron hydroxides. Anderson et al., (1973) and Chao and Anderson (1974) demonstrated the importance of these phases as being one of the primary mechanisms of attenuation for silver.

Hydrous oxides also attenuate metals by coprecipitation reactions. As the oxides form, various heavy metals of appropriate size, such as zinc and cadmium, will substitute within the mineral lattice and become a covalently bonded trace component of the oxide. This is a non-reversible reaction. Metals will be liberated only with the destruction of the mineral phase due to changes in the pH-Eh regime of the system. In addition, coprecipitation reactions with the hydrous oxides are an effective method of immobilizing the negatively charged chromate and selenate species that are stable under oxidizing conditions. The high concentrations of iron, and in many cases manganese, detected in shallow aquifer soils suggest that these phases are present throughout the facility.

In addition to sorption and coprecipitation, most heavy metals are attenuated at increasing pH by the direct precipitation of mineral phases. Cadmium, zinc, and lead are effectively attenuated by the formation of carbonate,

oxide, and hydroxide minerals at intermediate to high pH. Soil pH varies across the facility from a low of 3.9 in bay marsh soils to a high of 9.8 in the upland soils.

Adsorption by suspended organic matter usually involves the formation of strong chemical bonds, resulting in a non-reversible reaction. Chelates and coordination compounds are formed with the organic functional groups present in high molecular weight humic acids, resulting in complexes with high degrees of stability. Guy and Chakrabarti (1976) found that humic acids can maintain lead ions in a bound form at a pH of as low as 3.

Environments rich in organic matter such as marshes, wetlands, and subsurface environments rich in organic silts and clays provide abundant sites for the removal of heavy metals. Soils of marine derivation or influence at NAS Moffett Field should exhibit high concentrations of clays and organic acids (i.e., humic substances). In areas of higher fluvial influence, clays and hydrous oxides are expected to predominate.

23.3 CHEMICAL REQUIREMENTS OF TRANSPORT MODELING

Transport modelling will be performed during Phase II of the RI. Model selection has not yet been made; however, models under consideration include but are not limited to:

- SWIFT II, a two-dimensional finite difference model (Reeves et al., 1986)
- SWIFT III, a three-dimensional finite difference model (Ward, 1987)
- GEOFLOW, a two-dimensional and quasi three-dimensional finite element model for each horizontal layer, finite difference for each vertical layer (IT Corporation, 1986)
- Princeton Transport Code, same as GEOFLOW.

Each of these codes requires the interpretation of the chemical and physical information obtained at each site and the formulation of retardation factors and dispersion coefficients for the chemicals of concern. As was previously described, the calculation of retardation factors for organic chemicals

requires a knowledge of the organic carbon content of the soils as well as published octanol-water coefficients. For inorganic parameters, the distribution coefficient is a combination of the effects of adsorption and mineral solubility. The K_d s can be estimated based upon literature data, field observations, geochemical computer programs, experimental methods, and empirical formulas. The retardation factor can then be calculated using the same method described for organic compounds.

Dispersivity characteristics of a soil involves the properties affecting chemical constituent advancement due to spreading. Dispersion is comprised of two parts:

- Mechanical dispersion influenced by transverse and longitudinal dispersivity
- Molecular diffusion.

The longitudinal dispersivity is generally about 5 to 20 times larger than the transverse dispersivities (Freeze and Cherry, 1979). Based on site characteristics and comparisons with values from similar environments, a range of dispersivities can be selected for use in the models.

Diffusion coefficients for clayey materials have been reported in the literature and appropriate values will be selected for use in the models. The diffusion coefficient is generally an insensitive parameter. For usual ground water flow velocities, the effects of mechanical dispersion will outweigh those of diffusion.

24.0 PRELIMINARY RISK EVALUATION

24.1 INTRODUCTION AND APPROACH

The Phase I preliminary risk evaluation is based on a qualitative review of the Phase I Field Investigation data. The results of this review are used to perform a preliminary hazard assessment for the purpose of determining if any immediate and substantial hazards exist that may require immediate or interim actions. In addition, the Phase I assessment will identify any data gaps for additional sampling efforts.

The preliminary risk evaluation consists of the following sections:

- Identification of chemicals of concern
- Receptor survey
- Identification of migration pathways
- Identification of exposure pathways
- Hazard evaluation
- Preliminary environmental risk evaluation
- Conclusions and recommendations.

The preliminary evaluation compares the Phase I data with preliminary ARARs and appropriate risk-based criteria to determine if any immediate action is required and to identify those areas of potential concern for the quantitative baseline risk assessment to be reported in the Operable Units Report.

The Phase I data are reviewed to identify any data gaps which need to be addressed during the additional Phase II sampling and field investigations. Recommendations would include sampling designs for potentially contaminated areas or environmental media, type of analytical analysis required, and geophysical data necessary to model the migration of chemicals in the environment.

24.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

24.2.1 Data Evaluation Methods

Before analysis of the RI sampling data, all results were checked for consistency between duplicates and compared with results of the blank analyses. Duplicate samples were compared to the corresponding field samples to evaluate the validity of the results of the environmental analysis. No major inconsistencies were seen. The following types of blank samples were analyzed: rinse blanks, field blanks, trip blanks, and source water blanks. The results were evaluated to determine if chemicals seen in field data could have been introduced during the sample collection and analysis process. Additionally, laboratory blanks were evaluated by the laboratory. Summaries of the raw data are presented in Appendices C and D.

The physicochemical properties of each chemical determine the degree of partitioning into each environmental medium. Therefore, sampling results from each medium were evaluated separately. From the results, a preliminary list of chemicals of potential concern for each environmental medium tested at NAS Moffett Field was prepared. Each chemical found in a particular medium with at least one positive result (i.e., quantitative value above the method detection limit) was included on the preliminary list of chemicals of potential concern for that medium. Chemicals found during the sampling effort were subsequently eliminated from the list of chemicals of potential concern based on the following factors (EPA, 1989b):

- If the chemical was detected only once in the environmental medium, with the exception of some soil samples, as described later.
- If all detections were below:
 - Ten times the highest blank sample results associated with common laboratory contaminants
 - Five times the highest blank for other chemicals.
- If the range of potentially site-influenced concentrations was within the range of site-specific background values for inorganic constituents.

Soil samples were taken from a given area only once, either during monitoring well installation or as part of the soil boring sampling program. Ground

water sampling was monthly for one quarter and then quarterly for the next three quarters. A single, positive result for a chemical in a water sample was assumed to be an artifact. Similarly, a single positive result near the detection limit for a chemical in a soil sample was assumed to be an artifact. An exception, however, was A single sample from one soil boring at Site 1 that was found to contain several chemicals at levels well above their detection limits. Because of the number of compounds and the concentrations detected, this sample was assumed to represent a potential "hot spot" and these compounds were not eliminated from the list of chemicals of potential concern even though they were only encountered once. Further sampling is needed to verify these results.

Because of the wide-spread occurrence of several common laboratory contaminants in virtually all environmental sampling efforts, the EPA has developed new guidance for eliminating these common laboratory contaminants from potential concern (EPA, 1989b). This guidance states that for all common laboratory contaminants such as acetone, methylene chloride, and various phthalate esters, sample results should be considered positive only if the concentration in a sample exceeds ten times the maximum amount detected in any blank associated with that sample. If a blank contains chemicals that are not considered common laboratory contaminants, the site sample results should be considered valid if the sample exceeds five times the maximum amount detected in the associated blanks.

The third criterion for determining chemicals of potential concern is particularly important when the list of identified compounds contains inorganics that are ubiquitous in the environment. Care was taken to distinguish concentrations in each environmental medium from background concentrations. Background levels were established for both soil and ground water. Data obtained from the USGS and off-site areas identified during the RI for the Middlefield-Ellis-Whisman Area (Harding-Lawson Associates, 1987b) are listed in Table 24.2-1 and were used for comparison with concentrations found in soil samples. Inorganic concentrations are affected at NAS Moffett Field by the proximity to San Francisco Bay and the Leslie Salt Company evaporation ponds. The intrusion of saltwater minerals into the soil at the Naval Air Station would be expected to produce elevated levels of inorganics not related

to any on-site source area. Because of this, ranges of inorganic concentrations in soil were developed, as described in Section 3.5 and shown in Table 24.2-1. These ranges provide a baseline for inorganic concentrations found basewide which cannot be directly associated with any on-site source. Inorganics that were detected above regional background, but were within these on-site baseline ranges, were not removed from the list of chemicals of potential concern and have been noted as likely to be naturally occurring on site.

Ground water background data from the State of California Department of Water Resources (DWR, 1988) and well W10-06C at NAS Moffett Field are listed in Table 24.2-2. Well W10-06C is both upgradient of the identified source areas and is screened in Aquifer C, which has shown no signs of contamination (Section 3.4). The concentrations of inorganics found in well W10-06C are expected to be lower than those found in the shallower A and B aquifers and in areas closer to the north end of NAS Moffett Field due to the increased potential for saltwater intrusion in these areas. Elevated levels of calcium, sodium, magnesium, and other major saltwater ions in ground water at NAS Moffett Field indicate that saltwater intrusion is occurring in this area. Saltwater contains significant concentrations of many trace elements, including arsenic, copper, cadmium, lead, mercury, silver, and zinc. In addition to the normal metal content of seawater, this area of the San Francisco Bay has been shown to contain elevated levels of selenium, mercury, cadmium, arsenic, lead, chromium, copper, silver, nickel, and zinc (CSWRCB, 1990). The Leslie Salt Company evaporation ponds have the effect of concentrating these metals still further. Due to the saltwater intrusion there are currently no appropriate background data available for comparison with on-site concentrations of inorganic constituents in ground water. A complete discussion of background concentrations of inorganic constituents is given in Section 3.4.

Complete lists of all inorganic constituents found in the ground water at NAS Moffett Field are shown in Tables 24.2-3 and 24.2-4. The elevated heavy metal concentrations found in the ground water are associated with elevated levels of chloride, indicating the presence of saltwater intrusion (see Section 3.0). Therefore, these elevated heavy metal concentrations are considered to be associated with the saltwater intrusion. Based on these data, the presence

of these ions in ground water is not thought to result from activities associated with NAS Moffett Field.

24.2.2 Chemicals of Potential Concern

NAS Moffett Field is divided by the runways that run down the center of the air station. Site-related chemicals east of the runways are expected to migrate north toward a collection ditch that parallels the northern boundary of the station (Section 3.3). Water from this ditch is pumped off site into a canal that empties into Guadalupe Slough. Chemicals present in media west of the runways are expected to migrate northwest toward the marsh located in the northwest corner of the station (Section 3.3). Because chemicals present on opposite sides of the runways are expected to migrate to different areas, potential human and environmental receptors will be different. Chemicals of potential concern have, therefore, been identified separately for these two areas.

24.2.2.1 Evaluation of Areas East of the Runways

The following potential source areas have been identified east of the runways:

- Site 1: Runway landfill
- Site 2: Golf course landfill
- Site 3: Marriage Road ditch
- Site 4: Former industrial wastewater surface impoundments
- Site 5: Fuel farm french drains
- Site 6: Runway apron
- Site 7: Unpaved areas surrounding Hangers 2 and 3
- Site 11: Engine test stand area
- Site 13: Equipment parking area
- Site 19: Leaking tanks (Nos. 2, 43, 53).

No data are currently available for the four sumps and oil/water separators that make up the eastern portion of Site 15. Site descriptions are given in Sections 4.0 through 22.0.

Ground Water

Ground water contamination on the east side of the base is confined to the A1 and A2 subaquifers and the perched water found under the landfills (Section 3.4). Sixteen of the thirty identified chemicals of potential concern are limited to this perched water. No chemicals have been found in the ground

water below the A2 aquifer. The most commonly occurring compounds in this area are 1,2-dichloroethene (1,2-DCE), 1,1-dichloroethane (1,1-DCA), tetrachloroethene (PCE), trichloroethene (TCE), bis(2-ethylhexyl)phthalate (BEHP), and naphthalene. The other compounds listed in Table 24.2-5 are associated with only one or two sites; with the majority associated with the runway landfill (Site 1).

Chemicals of potential concern for ground water and the aquifers in which they have been identified are listed in Table 24.2-5. Due to the extremely high concentrations of major saltwater ions (i.e., sodium, chloride, bicarbonates, potassium, calcium) in the A subaquifer it is assumed that all inorganic contamination in this area is related to saltwater intrusion. Therefore, no inorganics have been included in this list as it is not possible to differentiate the high levels of inorganics in the A aquifer thought to result from saltwater intrusion from potentially lower levels that may have resulted from source areas. Furthermore, inorganic concentrations in the B and C aquifers are within background. Descriptions of the aquifers and their classification (i.e., A, B, and C) are given in Section 3.3.

Soil

The most commonly occurring compounds in this area are: BEHP, di-n-butylphthalate, 2-butanone, pyrene, toluene and carbon disulfide. The other compounds listed in Table 24.2-6 are associated with only one or two sites. With the exception of four compounds, all of these chemicals were found throughout the soil column. Acenaphthene, pentachlorophenol, 1,2,4-trichlorobenzene, and 4-chloro-3-methylphenol were found only in the top one meter of a single sample at Site 1. This sample is currently considered a potential "hot spot"; these chemicals may be removed from the list of chemicals of potential concern after review of the Phase II data. The currently identified chemicals of potential concern for soil at NAS Moffett Field are listed in Table 24.2-6.

24.2.2.2 Evaluation of Areas West of the Runways

The following potential source areas have been identified west of the runways:

- Site 8: Waste oil transfer area
- Site 9: Old fuel farm
- Site 12: Firefighting training area

- Site 14: Abandoned tanks (Nos. 19, 20, 67, and 68)
- Site 19: Leaking tank (No. 14).

No data are currently available for Sites 16 (Public Works Steam Rack Sump No. 60), 17 (Paint Shop Sump No. 61), 18 (Dry Cleaners Sump No. 66), or the five sumps and oil/water separators that make up the western portion of Site 15. Sites descriptions are given in Sections 4.0 through 22.0.

Ground Water

The aquifer system at NAS Moffett Field is described in Section 3.3. Nine chemicals of potential concern have been identified in the ground water for this area; all are common organic solvents. The highest concentrations detected were for TCE, acetone, and methylene chloride. All of the ground water contamination on the west side of the base is confined to the A1 and A2 subaquifers near Sites 8 and 9. No organic chemicals have been found in the ground water below the A2 subaquifer. Inorganics have not been included in this list because it has been concluded that the presence of inorganics is most likely resulting from saltwater intrusion and not from potential source areas. Of the 13 inorganics found above "background" in the A subaquifer, six are major saltwater ions (bicarbonate, calcium, iron, magnesium, potassium, and sulfate) and the other seven (aluminum, arsenic, beryllium, manganese, nickel, silver, and vanadium) are present in seawater. Chemicals of potential concern for ground water and the aquifers in which they have been identified are listed in Table 24.2-7.

Soil

The most commonly occurring compounds in the soil are: BEHP, di-n-butyl-phthalate, 2-butanone, toluene, benzoic acid, and the mixed xylenes. Each of the other compounds listed in Table 24.2-8 is associated with only a single site; with the majority being at the firefighting training area (Site 12). Eight compounds in Table 24.2-8 are identified as occurring only within the top meter of soil; the remainder of the compounds were found throughout the soil column.

24.2.3 Summary

A summary of the chemicals of potential concern in all sampled media at NAS

Moffett Field is presented in Table 24.2-9. Ground water contamination is confined to the A1 and A2 aquifers and the fill material leachate (Aquifer F) under the landfill Sites 1 and 2. This list will be re-evaluated upon completion of the Phase II investigation.

24.2.4 Uncertainties

There are three primary factors contributing to the uncertainty of determining chemicals of potential concern at NAS Moffett Field. The selection of representative background concentrations for inorganics in the soil and ground water was complicated by the unavailability of suitable on-site background data due to the generally industrial nature of the area and the potential for saltwater intrusion. Because of these difficulties a variety of regional background and on-site baseline data was used in evaluating inorganics.

The almost ubiquitous presence of several common laboratory contaminants in samples and blanks from both media, and the occasional occurrence of other compounds in various blanks, causes uncertainty as to whether certain organics are actually present or if they were introduced into the samples during collection and analysis.

The elimination of certain compounds due to their infrequent detection raises uncertainties as to whether these compounds may actually be present elsewhere but have not been found. Additional sampling being conducted in Phase II will reduce or eliminate this uncertainty.

There are also uncertainties involved in the identification of chemicals of potential concern. However, the procedures used were designed by the EPA (EPA, 1989b) and were applied here to obtain a health-protective list of all chemicals which may be present at the site, while providing for the elimination of chemicals which should not be considered to be of concern. Health-protective procedures include chemicals detected only once in soil samples taken from potential "hot spots", and the inclusion of chemicals known to be common laboratory contaminants.

24.3 PRELIMINARY EXPOSURE EVALUATION

The Phase I assessment consists of a detailed receptor survey based on review

of available demographical data and current and future land- and resource-use information. The assessment also identifies potential migration and exposure pathways for site-related chemicals. Exposure points are identified and site-specific exposure scenarios are developed.

24.3.1 Receptor Survey

The objective of the receptor survey is to identify potential human populations that may be exposed to site-related chemicals at NAS Moffett Field. The survey includes a review of current and future land-use and considers the relationship between land-use and the presence of potential receptor populations.

24.3.1.1 Land use

The current mission of NAS Moffett Field is to support antisubmarine warfare training and patrol squadrons. Today more than 5,500 military, 1,500 civilian, and 1,000 reservist personnel support nearly 100 P-3C Orion patrol aircraft assigned to nine squadrons (WESTDIV, 1985). Although no heavy manufacturing or major aircraft maintenance is performed at NAS Moffett Field, a significant amount of unit and intermediate level maintenance is accomplished (WESTDIV, 1985).

Approximately 1,500 acres of land at NAS Moffett Field are used for operations, training, ordnance storage, maintenance facilities, personnel support facilities, and single-person and family housing (WESTDIV, 1985). An additional 160 acres are leased for agricultural use as part of the station's ongoing land management planning program. Land uses at Moffett Field are divided in half by the runway system that is oriented northwest-southeast. The aircraft and flight operations are on the east side of the runway and the personnel support operations and housing are on the west side (WESTDIV, 1985).

The facility is bounded by salt evaporation ponds to the north, Stevens Creek to the west, U.S. Highway 101 to the south, and the Lockheed Aerospace Center (Lockheed) to the east. The evaporation ponds located to the north of the station are used by the Leslie Salt Company for the production of salt. These ponds lie between Moffett Field and San Francisco Bay (WESTDIV, 1985).

The remainder of the land surrounding NAS Moffett Field is used primarily for research and light industrial parks. The Ames Research Center occupies about 340 acres of land on the north and west borders of the station (WESTDIV, 1985). The MEW area companies are a group of microchip manufacturing facilities located to the south of Moffett Field (HLA, 1987b). As previously stated, Lockheed is located adjacent to the east boundary of the station.

The air traffic into NAS Moffett Field will continue to limit area land use in the future. The salt evaporation ponds located to the north of the station are anticipated to continue operations for the foreseeable future (WESTDIV, 1985). The present industrial and research parks are also expected to continue operations into the foreseeable future (WESTDIV, 1985). Undeveloped lands located near NAS Moffett Field have been zoned for industrial and research park development (WESTDIV, 1985). It is unlikely that any residential developments will be built in the area, given the presence of the station and the present heavy industrialization of the area.

Water supplies for these industrial complexes is presently provided via the San Francisco Aqueduct. The Hetch-Hetchy project import system of the San Francisco Water Department, which began in 1965, has furnished increasing quantities of water to local public entities and to NAS Moffett Field. Previous to this time well water was extensively used. Gradual subsidence of the land surface in the area has been observed since 1932. As of 1969, the local subsidence had virtually ceased and the outlook for further subsidence appears remote, with the present ground water demands. The water provided by the San Francisco Water Department is expected to be adequate to continue to provide fresh water to the growing communities of the area (WESTDIV, 1985).

24.3.1.2 Identification of Potential Receptor Populations

The purpose of this section is to identify those populations which may be exposed to site-related chemicals. However, for an exposure to a human receptor to occur, site-related chemicals must migrate from a source to a point where a human receptor may potentially contact, inhale, or ingest the chemical. The Phase I assessment is limited to the identification of all potential receptor populations and relating these potential receptor populations to identified migration and exposure pathways and points of exposure. Quantita-

tive evaluation of potential exposures for receptors that migration and exposure pathways link to a site-related source will be addressed in the Phase II baseline risk assessment to be presented in the Operable Units Report.

Generally, receptor populations are divided into two groups: on-site and off-site receptors. On-site receptors could include station personnel and families of military personnel that are residing on the station. On-site populations fall into two potential receptor categories; occupational and residential. Occupational receptors are those potentially exposed as a result of activities associated with duty assignments. The residential receptors may be potentially exposed to site-related chemicals from living on the station.

Potential off-site receptor populations could include people who work or live in the area surrounding NAS Moffett Field. The people who work in the surrounding area could include the employees of businesses located in the nearby industrial and research parks, and of adjacent businesses (e.g., service stations).

It is possible that a small segment of the identified receptors may be exposed from consuming fish or ducks harvested from the waters or wetlands surrounding the station. There is a duck hunting club located adjacent to the Leslie salt evaporation ponds (ENVIRON, 1981). Duck hunting season varies from year to year, but usually lasts approximately 2 to 3 months (Crossland, 1990). Several of the waters surrounding NAS Moffett Field are classified as potential areas for sport fishing, including Coyote Creek, Guadalupe Creek, Stevens Creek, and South San Francisco Bay (SFBRWQB, 1986). Ducks and fish may bioaccumulate chemicals either from surface waters containing site-related chemicals or within the food web. As a result, humans who consume these may be potentially exposed to site-related chemicals.

24.3.2 Migration Pathway Analysis

The purpose of this section is to describe the site-specific pathways related to chemical transport that may result in potential exposure points for human or environmental receptors. In general, the major routes of migration from a site such as NAS Moffett Field are via the air, surface water runoff, leachate from landfills, and leaching into ground water. Each of these environmental

pathways will be discussed. The different sites will be identified by site number (e.g., Site 1 is the runway landfill). The reader is referred to Section 24.2 for a list of the sites.

24.3.2.1 Air Pathway

Site-related compounds contained in soils may be released via volatilization. This would result in potential exposures to human receptors via inhalation. This migration pathway would be limited to highly volatile organic compounds found in the surface soils.

Particulate-bound chemicals may also be transported through wind erosion of soils. These chemicals would be limited to compounds that either have a high affinity for soils or a low vapor pressure, thus reducing the possibility of volatilization. This migration pathway would be limited to chemicals found in the surface soils.

24.3.2.2 Surface Water Runoff

Rain events may result in the erosion of soil containing site-related chemicals into runoff water. The 2,000-acre drainage area of NAS Moffett Field is essentially divided by the runway system which runs approximately north-south. Runoff from the west side of the runway drains via storm water collection pipes and ditches northwest of the runway. The water is collected in a drainage basin on the north side of the Ames Research Center and is discharged into a marsh area northwest of NAS Moffett Field. The west side of NAS Moffett Field is relatively flat, resulting in very minimal sheet flow as a result of rainwater runoff (Section 3.0). There are no signs of erosion occurring on the west side of the base (Section 3.0). Therefore, transport of site-related chemicals via erosion of soils is not considered an important migration pathway for the sites west of the runway.

Drainage on the east side of the runway accumulates in Marriage Road ditch, which drains into a perimeter ditch at the northern border of the station. Water from this collection ditch is pumped into an off-site canal that drains to Guadalupe Slough. Marriage Road ditch receives runoff from Sites 4, 5, 7, and 10. Any soils transported into Marriage Road ditch would accumulate in the perimeter ditch at the northern end of the station. Surface water runoff

and associated soil transport from Sites 2 and 11 would also collect in the perimeter ditch and in an evaporation pond at the north end of the station. No signs of erosion have been reported on the east side of the station. Therefore, transport of site-related chemicals via erosion of soils is not considered an important migration pathway for the sites east of the runway, including Site 10, (the runway).

Runoff at Site 1 accumulates in a flat-diked area just north of the site (IT, 1989a). Eroded channels are not apparent anywhere on the surface of the landfill (IT, 1989a). The landfill is covered mostly with gravel and debris, which increases the infiltration of precipitation. Site-related chemicals were not found in soil samples from the embankments of the landfill or in sediment samples taken from the drainage area next to the landfill (Section 4.4). From the analytical results, it would appear that site material is not being transported via runoff at this site.

24.3.2.3 Landfill Leachate

Leachate from the two abandoned landfills (Sites 1 and 2) may transport site-related chemicals into either surface or ground water. Leachate in Site 1 appears to move with the surface water to the diked flat area north of the site where evaporation occurs. Leachate may also leave the site beneath the runway extension. The evidence for this is the anomalously low water levels in monitoring wells near the runway extension and the existence of an excavated channel in historical aerial photographs. The excavated channel could act as a potential migration pathway for leachate into the ground water. Water flowing in this direction would accumulate in the adjacent marsh (IT, 1989a).

Leachate materials from Site 2 probably migrate via the ground water into the adjacent perimeter ditch which parallels the northern boundary of the station (Section 3.4). Water is pumped from the basin over the dike and into a canal which leads to Guadalupe Slough (IT, 1989a).

24.3.2.4 Ground water

There are at least three aquifers located under NAS Moffett Field. The three aquifers are separated by clay and silt layers which range from 5 to 40 feet

thick (IT, 1989a). There is an upward hydraulic gradient from the deeper aquifers. Therefore, ground water underlying Moffett Field would migrate from the lower aquifers to the shallow aquifer. The B aquifer is separated from the A aquifer by a clay aquitard 5 to 10 feet thick (Section 3.4.2). The C aquifer at NAS Moffett Field is semiconfined under a clay aquitard that ranges in thickness from 20 to 40 feet. There is not a hydraulic connection between the B and C aquifer (Section 3.3). Presently the chemicals of concern in the ground water are restricted to the upper aquifers (Section 21.2). Preliminary hydrogeological data indicate that the lower aquifer has a greater head than the upper aquifer. The head differential and the thick aquitard that separates the two aquifers would prevent the natural migration of chemicals into the lower aquifer (Section 3.3). However, there are several abandoned wells on the station which may serve as potential conduits between the aquifers (K/J/C, 1989). The active wells have been properly installed; therefore these wells will not act as potential conduits (ESA, 1986c). The discussion of migration of site related chemicals via ground water will be limited to the A and B aquifers.

The ground water in the A aquifer flows northeastward. An anomalous flow pattern exists at the northeastern section of NAS Moffett Field. A pump station is located at the end of the perimeter ditch, which collects runoff and pumps it into Guadalupe Slough via a northeasterly trending drainage canal. Ground water contours and water level information indicate that this pumping station has a significant effect on shallow ground water movement, and locally creates a concentric drawdown pattern around the pump station. Anthropomorphic constituents in the ground water stemming from activities at the sites located on the eastern side of the station, including Site 1, will migrate towards the pumping station (Section 3.0). At shallow ground water levels, the ground water may discharge into Marriage Road ditch or at the northern end of the base (Section 3.0). Water from both collection ditches is ultimately pumped over the dike into the off-site canal leading to Guadalupe Slough. Guadalupe Slough flows into Coyote Creek which feeds into San Francisco Bay (Section 3.0).

The discharge areas for the ground water underlying the west side of the station are not well defined. The ground water probably discharges into the

marsh area located on the northwest corner of the station. This marsh area extends from NAS Moffett Field west to the edge of Stevens Creek. The marsh is separated from Stevens Creek by a berm; however, the water from the marsh probably infiltrates into the creek (Section 3.0).

The ground water in the B aquifer discharges directly into San Francisco Bay. Site-related chemicals have not entered the B aquifer at the present time (Section 24.2).

24.3.3 Identification of Exposure Pathways

Potential human exposures may occur by primary pathways (e.g. dermal contact, inhalation, or direct consumption of soil or water), or through secondary pathways involving the transfer of site-related chemicals through a food chain or web. Both the primary and secondary pathways will be analyzed in this section to evaluate their applicability to NAS Moffett Field.

24.3.3.1 Primary Pathways

Exposure to site-related chemicals in soils may result from dermal contact or inhalation of organic vapors or particulate-bound chemicals. Access to sites which have elevated levels of chemicals in the soil has been restricted to authorized personnel. A policy governing access to these areas has been issued by the Environmental Division Director at NAS Moffett Field. This policy directs all workers to treat all excavations as confined spaces and to consult safety officers for appropriate guidance with respect to protective equipment and work period limitations. Furthermore, the policy directs workers to consider all excavated soils and ground water as potentially contaminated materials (NAS Moffett Field, 1989). Given the policies restricting the type of activities which take place in these areas and the institutional controls on those activities, it is unlikely that base personnel will be exposed to harmful levels of site-related chemicals by dermal contact.

Potential exposure of humans may result from the inhalation of organic vapors from the vaporization of volatile organic compounds in the surface soil. However, the potential impact of this exposure pathway is mitigated by dispersion of any off-gassing from the soils into large air volumes. In addition, the sites being studied are either located in remote areas of the station or

in areas where potentially exposed receptors could be described as transient; that is, remaining in the immediate area for short periods of time.

A receptor may also inhale particulate-bound chemicals that have been suspended in the air from the wind erosion of soils. The amount of suspended soil particulates in air range from 0.1 to 0.15 mg/m³ (Paustenbach, 1989). It has been estimated that of all airborne particulates, only 30 to 50 percent comes from soil; the rest is apparently due to products of combustion, tire wear, and other sources (Paustenbach, et al., 1986). The remediation sites at NAS Moffett Field make up only a small percentage of the total land area. Therefore, the amount of suspended soils which may originate from these sites could be expected to be very small. The relatively small contribution of particulates (and consequently smaller contribution of chemicals) reduces the importance of this exposure pathway.

Well surveys show that no known domestic wells exist that draw water from the shallow aquifer in the study area vicinity (K/J/C, 1988b). Although there is sufficient water within this aquifer, it is unlikely that the shallow water aquifer would be used as a water source. Historically the ground water in the Southern San Francisco Bay Region had been over-pumped, and this has resulted in saltwater intrusion and land surface subsidence. To prevent further destructive effects of over-pumping, rigid basin management plans were implemented, consisting in part of pumping controls. Since then, there has been no increase of saltwater intrusion or land surface subsidence. Saltwater intrusion has occurred in the A and B aquifers and extends under the northern portion of NAS Moffett Field (Section 3.5.2). If drinking water wells were placed in the shallow aquifers along the southern portion of the base, the resulting drawdown would result in increased saltwater intrusion (IT, 1989a). The increased saltwater intrusion would eventually destroy the potability of the ground water in these aquifers. The A and B aquifers could only provide potable water for a limited period of time. Domestic water at the base is supplied by the San Francisco Aqueduct. It is unlikely that this water supply source would not continue in the future (WESTDIV, 1985). Given the limited capacity of the shallow aquifers to produce potable water and the presence of a domestic water supply via the San Francisco Aqueduct, it is unlikely that the A or B aquifers would be used as a drinking water source.

Therefore, direct exposure through drinking water is not considered a viable exposure pathway.

The only water wells located in the area are agricultural wells used for the irrigation of crops and watering golf greens and other areas on NAS Moffett Field. These wells draw water from the deep C aquifer (K/J/C, 1988b). No chemicals have been detected in this aquifer and there is little potential for chemicals to migrate into it. Therefore, potential exposure to site-related chemicals from direct contact with water from these wells is not considered to be a viable route of exposure for either on-site or off-site populations.

The shallow aquifer discharges into the drainage canal and the marsh on the northwest corner of the station. Marriage Road ditch also receives discharge from the A aquifer during high ground water conditions (Section 3.3). Swimming or other water sports activities do not occur due to the unfavorable nature of the area for these activities. Prolonged contact of large areas of exposed skin with the waters in these areas does not appear likely to occur. The water which is discharged into these areas migrates or is pumped into nearby creeks, (i.e., Guadalupe Slough, Coyote Creek) and Stevens Creek (Section 3.0). Swimming in these areas is unlikely since the sections of these creeks that can potentially receive ground water are located either in highly urbanized areas or within mud flats and marshy areas and are, therefore, unappealing and difficult to access for swimming. Therefore, consumption of, or dermal contact with, surface water does not represent a pathway with long-term exposure potential.

Analysis of the primary exposure pathways indicate that, under current and predictable future usage patterns, no direct pathways for long-term routine exposures of human receptors exist. Any potential exposures that could occur would be random and sporadic events which would be unpredictable and not likely to be regularly repeated by the same individual receptor. These exposure pathways will not be considered further in the risk evaluation.

24.3.3.2 Secondary Pathways

The secondary pathways represent biological routes by which chemicals accumulate from environmental matrices into the tissues of plants and animals, which

are then consumed by higher animals or humans. Human activities in the area include duck hunting and fishing (ENVIRON, 1981).

Ducks may bioaccumulate site-related chemicals from their food, which consists of aquatic plants and invertebrates (Krull, 1970). Duck hunting season lasts for 2 to 3 months per year (Crossland, 1990). The possession limit restricts the number of ducks persons may have in their possession, either in the fields or at home, at any one time. In 1989 the limit was four ducks (Crossland, 1990). Therefore, the amount of meat a person can potentially consume per year is limited because of the restricted hunting period and the number of ducks a person may possess.

Ducks are relatively small, usually containing less than one pound of edible meat (Crossland, 1990). Ducks are migratory birds and would stay in the area for a limited time period. In addition, the amount of vegetation which may bioaccumulate site-related chemicals is relatively small in comparison to the amount of food which is available in the area (U.S. Fish and Wildlife Service, 1986). The amount of site-related chemicals which would be bioaccumulated by a duck could be expected to be minimal. From these considerations, consumption of ducks is not considered a viable exposure pathway for the general population.

Aquatic life has been identified as a secondary pathway for a number of water-borne chemicals which have affected human population (Belton, 1986). Guadalupe, Stevens, and Coyote Creeks have been classified by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) as suitable for use for ocean commercial and sport fishing (SFBRWQCB, 1986). Commercial and sport fishing also take place in San Francisco Bay. The bioaccumulation of site-related chemicals in fish and other commercially important marine life may result in the exposure of human receptors to site-related chemicals.

Consumption of fish may be a viable secondary pathway. Additional information concerning the potential concentration of site-related chemicals in the water, and the amount of fish harvested from these waters that are consumed, is needed to quantitatively evaluate this pathway for the risk assessment to be presented in the Operable Units Report.

24.4 IDENTIFICATION OF ARARs

The remedial investigation/feasibility study (RI/FS) was conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and in conformance with the guidelines, criteria, and considerations set forth in the National Contingency Plan (NCP) and the Superfund Amendments and Reauthorization Act (SARA). Consistent with the CERCLA/SARA/National Contingency Plan (NCP) framework is the requirement that the remedial action process must comply with all legally applicable or relevant and appropriate requirements (ARARs). Applicable requirements are those federal and state requirements that would apply to conditions at a CERCLA site under any circumstance. Federal statutes that are specifically cited in CERCLA include the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act. Relevant and appropriate requirements are those federal and state human health and environmental requirements that apply to circumstances sufficiently similar to those encountered at CERCLA sites. In such cases, application of these requirements would be appropriate although not mandated by law. Relevant and appropriate requirements are intended to carry the same weight as legally applicable requirements.

The agency has also identified certain guidance as to-be-considered material (TBC). TBCs are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. In some circumstances, TBCs will be considered as part of the Operable Units Report risk assessment and may be used in determining the necessary level of cleanup for protection of health or the environment. Therefore, TBCs will not be discussed as a part of this report.

EPA has provided guidance on the overall application of the ARARs concept into the RI/FS process (EPA, 1988c). More specific guidance on compliance with ARARs has also been provided by the agency (EPA, 1987; EPA, 1988c; EPA, 1989a). In accordance with this guidance, ARARs are to be progressively identified and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entails the survey of all potential ARARs for the remedial action process at the subject site. The potential ARARs considered

for NAS Moffett Field site were categorized into the following EPA-recommended classifications:

- Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values for each chemical of concern. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment.
- Location-specific ARARs are restrictions placed on the concentration of a chemical or the conduct of activities solely because they occur in special locations.
- Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to waste management and site cleanup.

The next step in the ARARs process was the integration of the statutory and regulatory requirements with site-specific factors to evaluate whether a site is currently in compliance with all public health and environmental standards. The ARARs were selected based on the migration and exposure pathway analysis (Sections 24.3.2 and 24.3.3).

The degree to which site-specific factors are incorporated into the ARAR development process varies considerably. In the case of hazardous chemicals, the evaluation of site-specific factors is an integral part of the ARARs process even when prerequisites based on statutory or regulatory requirements exist (EPA, 1988d). As an example, for Maximum Contaminant Levels (MCLs) promulgated under the SDWA to be considered as ARARs at a site, the surface water or ground water media under consideration should be demonstrated to be potable and utilized as drinking water, either currently or at some planned future date. Flexibility is also provided in modifying a standard such as an MCL based on evidence that site-specific factors are different than those used in the derivation of the MCLs.

For chemicals for which ARARs are not available, EPA has provided guidance on the use and application of TBCs, such as carcinogenic potency factors (CPFs) or reference doses (RfDs) (EPA, 1987, EPA, 1988c; EPA 1989a). While not actually ARARs, these data may be used to determine risk-based cleanup levels

in a site-specific approach. This will be addressed in the Operable Units Report and the FS phase of the project.

The establishment of final federal and state ARARs for hazardous chemicals for evaluation in the Operable Units Report risk assessment. Site-specific factors were used to develop appropriate exposure scenarios that defined the bounds of the risk estimates for each remedial alternative.

Tables 24.4-1 through 24.4-3 present the potential federal and state ARARs reviewed and those ARARs that have been identified as potentially applicable for NAS Moffett Field. No action-specific ARARs were identified for NAS Moffett Field.

- Table 24.4-1 - Standards, Requirements, Criteria, or Limitations Evaluated for ARARs
- Table 24.4-2 - Source Listing for Chemical-Specific ARARs
- Table 24.4-3 - Source Listing for Location-Specific ARARs.

A brief statement of the rationale for the selection of each entry is also provided. A discussion of the chemical-specific ARARs is given in Sections 24.5 and 24.6.

Location-specific ARARs were identified for the NAS Moffett Field (Table 24.4-3). The majority of the ARARs address the potential impact of site-related chemicals upon the surrounding wetlands (Section 24.6). The Coastal Zone Management Act requires that any federal activity is consistent with the state's Coastal Zone Management Plan, in this case, the Water Quality Control Plan, San Francisco Bay Basin Region. The Water Quality Control Plan states that the South Bay below the Dumbarton Bridge is a unique hydrodynamic and biological environment. Therefore, "site-specific water quality objectives are absolutely necessary in this area" (SFBRWQCB, 1986). The potential water quality objectives for the site are discussed in Sections 24.5 and 24.6.

24.5 HAZARD EVALUATION

Analysis of the exposure pathways (Section 24.3.2) indicated that there were no viable primary exposure pathways for human receptor populations that described repeated, long-term exposures. However, a potential secondary

pathway may exist from consumption of fish which have bioaccumulated site-related chemicals.

Quantitation of potential chemical intakes based on the consumption of fish is beyond the scope of this hazard evaluation. Water quality criteria for fish consumption has been published under the Clean Water Act for some of the chemicals of concern for ground water (Table 24.5-1), but criteria have not been developed for all of the chemicals of concern (EPA, 1986). To estimate recommended water quality criteria relevant to human risk consumption for those chemicals which do not already have criteria, information will be collected concerning the amount of fish consumed from the area and the potential for each chemical to bioaccumulate. The water quality criteria only applies to those waters in which the fish live. The concentration of site-related chemicals in the surface waters will be estimated, using appropriate models, to take into account ground water discharge and the dilution of site-related chemicals into the surface waters.

For the purposes of this hazard assessment, the maximum concentration of the chemical in ground water was compared to the chemical-specific water quality criterion for fish consumption (Table 24.5-1). The question of whether site-related chemicals in the upper aquifer have the potential to migrate into surface waters that provide habitats for fish remains to be answered. Additional data are required to model the potential migration and uptake.

The chemicals whose concentrations are below the water quality criteria for fish consumption, will be eliminated as potential chemicals of concern. This is a very health-protective assumption because the expected dilution of the ground water into any receiving surface water body would be expected to result in surface water concentrations which are far below the concentrations measured in the ground water. Therefore, comparison of the maximum ground water concentration at the site with water quality standards provides a large margin of safety.

Chemicals detected in the ground water on the east side of the station which exceeded the water quality criteria were: 1,2-dichloroethene, 1,1-dichloroethene, trichloroethene, tetrachloroethene, and carbon tetrachlo-

ride. Trichloroethene and tetrachloroethene were within an order of magnitude of the water quality criteria. 1,1-Dichloroethene and carbon tetrachloride were within two orders of magnitude. The chemicals detected in the ground water on the west side of the station include 1,1-dichloroethene, 1,2-dichloroethene, and trichloroethene. All of these chemicals were within three to four orders of magnitude of the water quality criteria. Because of these extremely conservative assumptions, no immediate hazard appears to exist. However, these chemicals, and chemicals for which ambient water quality criteria do not exist, will be quantitatively evaluated in the Operable Units Report.

24.6 ENVIRONMENTAL EVALUATION

The purpose of the preliminary environmental risk assessment is to evaluate the potential impact of site-related chemicals upon the environment. The environmental assessment includes identification of possible environmental receptors, including threatened or endangered species. Maximum chemical concentrations in the ground water will be compared with the appropriate ARARs, when selected, to determine if these chemicals are a potential threat to environmental populations.

24.6.1 Identification of Environmental Populations

The following is a discussion on the major plant and animal communities found on or near NAS Moffett Field. A discussion of endangered species is given in Section 24.6.1.3.

24.6.1.1 Flora

Most of NAS Moffett Field that is not covered by buildings or other structures, is either paved or planted with typical urban ornamental plants. Approximately 160 acres of land is under agricultural cultivation. The northwestern portion of the station contains some areas where vegetation grows in a wild state (ENVIRON, 1981).

The area just north of NAS Moffett Field is within the historic margin of San Francisco Bay and was once open to tidal action. Because the area is now bordered by commercial salt evaporation ponds and dikes on the bayside and contains no open slough channels, regular tidal action has been eliminated.

The absence of tidal inflow and the use of the site for storage of storm water has resulted in changes to the plant community. Present vegetation types are distributed according to residual salt concentrations in the bay mud spoils, hydrologic conditions, and the level and salinity of drainage water. Plant distribution as a result of dikes and roads reflect man-made alterations to the area (ENVIRON, 1981).

Major vegetation types found just north of NAS Moffett Field include salt marsh, brackish marsh, fresh water marsh, and ruderal vegetation (ENVIRON, 1981). A description of each of the vegetation types is given in the following paragraphs.

Salt marsh communities are found in estuaries, bays, and other areas that are protected from wave action and strong winds from the open coast. The soil is generally very wet, and in some areas it is periodically inundated with salt-water by tidal action (Ornduff, 1974). Salt marsh vegetation closest to NAS Moffett Field is found within the edges of Stevens Creek and Guadalupe Sough. Cordgrass, pickleweed (Salicornia sp.) and salt grass (Distichlis spicata) grow at different elevations along with other halophytic species (ENVIRON, 1981).

Brackish marsh vegetation covers a large portion of the area immediately north of NAS Moffett Field. During the winter, this area, which is bordered by wetland vegetation, functions as a storage pond. In the summer and fall month, lower water levels present different conditions, and vegetation such as annual species, might cover a larger area of the basin (ENVIRON, 1981).

Freshwater marsh vegetation grows along the southeastern margin of the brackish marsh where salinity levels are lower. Clumps of cattails (Typha sp.), sedges (Carex sp.), and rushes (Juncus sp.) are distributed over a 100-foot-wide corridor crossed by several water channels (ENVIRON, 1981).

Ruderal vegetation, which consists of transitional opportunistic plant species, is evident along the perimeter drainage ditch and Stevens Creek, but becomes sparse-to-nonexistent on the northern border of the brackish marsh, where high soil salinity and fluctuating water levels may prohibit establish-

ment of a ruderal margin. Ruderal vegetation occurs on all levees and roads around the perimeter of the brackish marsh. Low forms such as cranesbill (Geranium dissectum), sweet clover (Melilotous sp.), and vetch (Vicia sp.) subtend to the hardy annuals, such as mustard (Brassica sp.), thistle (Cirsium sp.), and sweet fennel (Foeniculum vulgare), which provide a thick border along most levee roads. Other abundant species include various grasses (Graminae sp.), curly-leaved dock (Rumex cirpus), and the rare marsh gum plant (Grindelia humilus) (ENVIRON, 1981).

24.6.1.2 Fauna

Wildlife in the area consists of a variety of migratory and wintering birds, visiting birds from nearby bayfront and open water habitats, and several resident species of birds and small animals. A variety of waterfowl species frequent both the brackish marsh and the adjacent freshwater marsh. Local duck clubs report that wintering duck species are abundant on the salt ponds immediately adjacent to the station. Other than in a small section of Stevens Creek, fresh water marshes are uncommon in this region of the South Bay, and this marsh may be of importance as nesting habitat to local waterfowl (ENVIRON, 1981).

The brackish marsh provides habitat for shorebirds. The black-necked stilt (Himantopus mexicana), killdeer (Charadrius vaciferus), least sandpiper (Erolia minutilla), and the American avocet (Recurvirostra american) feed in the ponded areas. Other local species associated with salt marshes include the great blue heron (Ardea herodias), the great egret (Casmerodius albus), cinnamon teal (Anas cyanoptera), the American coot (Fulica americana), and the song sparrow (Melospiza melodia). The ring-billed gull (Larus delawarensis), Bonaparte's gull (Larus philadelphia), western grebe (Aechmophorus occidentalis), eared grebe (Podiceps caspicus), and the Forester's tern (Sterna forsteri) would be expected to be occasionally present near the brackish marsh (ENVIRON, 1981). Burrowing owls and their burrows have been observed in the northeastern section of the station.

The numerous salt evaporator ponds lining the South Bay provide significant habitat for several species of birds. The endangered California least tern and other birds prefer to nest on levees bordering salt ponds. A large colony

of eared grebes bred in the salt ponds at Moffett Field in 1983. It is the only known nesting ground of the eared grebes in San Francisco Bay (ENVIRON, 1981).

The most conspicuous mammal near NAS Moffett Field is the California ground squirrel (Spermophilus beecheyi), whose burrows are numerous along the wetland levees. Other mammals include the grey fox (Urocyon cinereoargenteus), raccoon (Procyon lotor), black-tailed hare (Lepus californicus), striped skunk (Metaphous mephitis), feral cat (Felis domestica), and California vole (Microtus californicus).

Nearby Mowry Slough and Guadalupe Slough are used by harbor seals (Phoca vitulina) as haulout areas throughout the year. Mowry Slough is the most important haulout and pupping area in southern San Francisco Bay. About 250 to 350 adult seals and 50 to 90 pups are present during the peak months of March through August (NOAA, 1986).

Only remnant runs of the anadromous steelhead trout (Salmo gairdneri) and possibly, an occasional king salmon (Oncorhynchus tshawytscha), are present in Coyote Creek. About 20 pairs of steelhead trout migrate into Coyote Creek. These populations are very low because of major habitat alterations in the headwaters of Coyote Creek and other nearby streams. Almost all of these streams are dammed or diverted in this area. There are no plans to improve the condition of the streams for use by anadromous fish. Some anadromous fish are present in the lower Bay, notably white sturgeon (Acipenser transmontanus) and striped bass (Morone saxatilis), but this area is not a critical habitat for either species. A number of anadromous fish species are caught by recreational and commercial fishermen, primarily for use as bait. The most important are shiner perch (Cymatogaster aggregata), staghorn sculpins (Leptocottus armatus), long-jaw mudsuckers (Gillichthys mirabilis), and gobies. Crangon shrimp (Crangon sp.) are also harvested by about 15 to 20 commercial trawlers for use primarily as bait and, occasionally for food. Recreational fisherman also harvest sturgeon, sharks, rays, jacksmelt, and striped bass in the southern Bay (NOAA, 1986).

24.6.1.3 Endangered, Threatened, and Rare Species

The Endangered Species Act (16 U.S.C. 1531 et seq.) provides that all federal agencies shall carry out programs for the conservation of listed endangered and threatened species. These programs ensure that actions authorized, funded, or carried out by the agencies are not likely to either jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of these species that is determined by the Secretary of the Interior to be critical.

The list of endangered and threatened animal and plant species is published in the Federal Register 50 CFR 17.11-17.12. The official State of California listing of endangered and rare animals is contained in the California Code of Regulations, Title 14, Section 670.5 (State of California, DWR, 1983).

The California Native Plant Protection Act of 1978 assigns primary responsibility to the Department of Fish and Game for determining California plants that are to be listed as endangered or rare. A species is endangered when its prospects of survival and reproduction are in immediate jeopardy. A species is rare when (although not presently threatened with extinction) it is present in such small numbers throughout its range that it may become endangered if its present environment worsens. As of November 20, 1979, the State of California has listed 75 endangered and 49 rare plants (California Native Plant Society, 1980).

The California Department of Fish and Game uses the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California as their species-of-concern list (California Native Plant Society, 1980).

The following list presents information about the endangered, threatened, and rare species that may inhabit areas near NAS Moffett Field:

- California least tern (Sterna albifrons browni)
 - Federal status: endangered
 - State of California status: endangered
 - Habitat: beaches, bays, oceans, and estuaries
 - Food: small fish, marine life, and large insects (Peterson, 1961)

- Preferred prey: anchovy, shiner perch, topsmelt, killifish, jacksmelt, California grunion, and mosquito fish (NAVFACENGCOM, 1982)
- Comments: This species has been observed nesting on levees in Fremont, which is approximately 5 miles northeast of NAS Moffett Field, and at other locations in South San Francisco Bay (ENVIRON, 1981).
- California clapper rail (Rallus longirostris obsoletus)
 - Federal status: endangered
 - State of California status: endangered
 - Habitat: salt marshes and salicornia beds along the Pacific coast (Peterson, 1961)
 - Food: aquatic plants, insects, frogs, crustaceans, mollusks, seeds, and buds (Peterson, 1961).
- California black rail (Laterallus jamaicensis coturniculus)
 - Federal status: not listed
 - State of California status: rare
 - Habitat: salt marshes and salicornia beds along the Pacific coast (Peterson, 1961)
 - Food: aquatic plants, insects, frogs, crustaceans, mollusks, seeds, and buds (Peterson, 1961)
 - Comments: Both California clapper rails and California black rails may be present in the salt marsh corridors of Stevens Creek and have been sighted at Guadalupe Slough; both species may occasionally visit the wetlands adjacent to NAS Moffett Field to forage in the areas of dense tidal marsh vegetation (ENVIRON, 1981).
- Brown pelican (Pelecanus occidentalis)
 - Federal status: endangered
 - State of California status: endangered
 - Habitat: salt bays and oceans (Peterson, 1961)
 - Food: mainly fish and crustaceans (Peterson, 1961); feeds mostly on anchovies (NAVFACENGCOM, 1982)
 - Comments: abundant in Jagel Slough near NAS Moffett Field from August to October (ENVIRON, 1981).
- Salt marsh harvest mouse (Reithrodontomys raviventris)
 - Federal status: endangered
 - State of California status: endangered
 - Habitat: coastal salt marsh; found only in San Francisco Bay area (Ingles, 1965); prefer dense salt marsh vegetation consisting of pickleweed or a combination of pickleweed and alkali heath, with a border of ruderal habitat
 - Food: seeds and fruits, prefers wild plants (Ingles, 1965)
 - Comments: The salt marsh along Stevens Creek is a potential habitat area; during periods of inundation, mice from the Stevens Creek wetlands may invade the nearby ruderal vegetation area (ENVIRON, 1981).
- Marsh gum plant (Grindelia humilis)
 - Federal status: not listed

- State of California status: candidate rare species (ENVIRON, 1981)
- California Native Plant Society status: rare
- Habitat: salt marsh
- Comments: Two specimens were located on the Stevens Creek levee bordering the brackish marsh (ENVIRON, 1981).

24.6.2 Environmental Hazard Assessment

The regional ground water gradient is northeastward, toward San Francisco Bay. The ground water in the shallow aquifer may recharge into the low areas on the north side of the station or to San Francisco Bay. Potential areas of discharge located between San Francisco Bay and NAS Moffett Field include the perimeter ditch, the marsh located north of the runway, and Stevens Creek (Section 3.0). The plants, wildlife, and aquatic organisms found in these areas may be potential environmental receptors for any site-related compounds which are transported via the shallow ground water aquifer.

Wildlife and fish may be exposed to site-related chemicals in the shallow aquifer. The animals and the birds which inhabit, or feed in, the area may use the drainage canal on the north side of NAS Moffett Field as a drinking water source. The marsh located at the northeast corner of the station may be of importance as nesting habitat to local waterfowl (ENVIRON, 1981). These birds may be directly exposed to site-related chemicals in the marsh. Mammals which hunt in the marsh may also drink from the small shallow pools of fresh water.

The water located in the surrounding creeks is brackish from the inundation of saltwater from the bay. Fish and other aquatic organisms which inhabit these waterways may also be exposed to site-related chemicals which have been transported off-site via the ground water. Estuarine organisms which inhabit San Francisco Bay may also be exposed to chemicals in the A aquifer which could be transported to the bay via Coyote and Stevens Creek.

The Clean Water Act has ambient water quality criteria for some priority pollutants. These criteria represent the maximum concentration to which aquatic organisms may be chronically exposed without adverse effect (EPA, 1986). None of the chemicals of concern identified in the ground water have water quality criteria (Table 24-6.1).

Further data is required before any conclusions can be drawn concerning potential risks from exposure of environmental receptors to site-related chemicals. During Phase II data will be collected to better characterize the fate of site-related chemicals and identify environmental receptors. Information is needed concerning the discharge and potential dilution of ground water into the bodies of surface water in the area. Species present that represent the most sensitive species and endangered species present at potential points of exposure, will be identified.

24.7 CONCLUSIONS AND RECOMMENDATIONS

The chemicals present in the environmental media at NAS Moffett Field should be quantitatively evaluated to assess potential risks to human health from the consumption of fish which have bioaccumulated site-related chemicals. This will be addressed in the Operable Units Report risk assessment. Environmental receptor populations include terrestrial mammals, birds, and freshwater and marine populations. Additional information is necessary before the potential impact of site-related chemicals on these populations can be evaluated.

The Operable Units Report risk assessment will quantitatively estimate the potential risk to human health and the environment. The following information is needed for a complete risk assessment.

- Additional soil analysis at Site 1 to verify or refute the presence of a "hot spot".
- The amount of fish harvested from the area and the contribution to the local diet.
- Characterization of the regional surface water hydrogeology, including the flow rate for nearby rivers.
- Characterization of environmental receptor populations, including the presence of sensitive and endangered species.

This information will be integrated to present an assessment of the potential health and environmental impacts, if any, from the potential exposure of human and environmental receptors to site-related chemicals at NAS Moffett Field.

25.0 CONCLUSIONS AND RECOMMENDATIONS

The Phase I investigation provided information to allow preliminary characterization of the geology and hydrogeology at NAS Moffett Field, and of the nature and extent of contamination at several sites. Conclusions and recommendations will be summarized for each site following a discussion of the general findings of the investigation.

25.1 GEOLOGY AND HYDROGEOLOGY

Drilling and logging of subsurface materials in the Phase I investigation confirmed the complexity of the geologic section beneath NAS Moffett Field. The stratigraphy was interpreted from electric and boring logs to be representative of predominantly deposition in an estuarine environment. Episodes of marine transgression, probably coincident with sea level rise during interglacial periods of the Pleistocene, resulted in laterally extensive quiet water deposits of clay, and possibly some extensive shallow water sands. Coarse grained units of estuarine deposition are composed of thin stringers of sand and gravel interbedded with thin clays in about the upper 60 feet of section, or of thicker, more continuous sand and gravel with clay interbeds in the interval from about 60 to 125 feet bls. Thick sand and gravel units greater than 165 feet bls may represent shallow water marine deposition, where continuous, or estuarine channel deposition. The laterally continuous clays of the marine transgressions are most evident between these three main sand and gravel units and are used to delineate the aquifers beneath the station.

The three main aquifers at NAS Moffett Field are designated the A, B, and C aquifers. The uppermost aquifer extends to about 60 feet bls and is designated the A aquifer. Previous studies divided the upper section into 20-foot and 45-foot aquifers (Iwamura, 1980), and into corresponding A and B1 aquifers (HLA, 1987). In initial work at NAS Moffett Field, the A, B1, B2, B3, and C aquifer nomenclature of HLA from the adjacent study area (MEW Companies) was used. Data from the Phase I study indicate that the B1 aquifer has hydrologic and geologic characteristics which are more similar to the A aquifer than to the B2 and B3 subaquifers. Thus in this study, the uppermost two units were designated the A1 and A2 subaquifers of the A aquifer. The A2

subaquifer is correlative to the B1 subaquifer of the HLA study (1987). To avoid confusion between study areas, the B1 nomenclature is not used for NAS Moffett Field; thus the B2 and B3 subaquifer designations are consistent and have not changed.

The A2/B2 aquitard ranges from about 5 to 25 feet in thickness and lies at about 45 to 60 feet bls. The B aquifer is in the interval from about 60 to 125 feet bls and, as discussed above, is divided into the B2 and B3 subaquifers. The thickest aquitard in the area is the B/C aquitard and it separates the upper and lower aquifers of Iwamura. This aquitard is about 15 to 30 feet thick and lies in the interval from 135 to 165 feet. The lower most aquifer investigated in this study is the C Aquifer. In initial studies at the station and in previous studies in the area, the lower aquifer of Iwamura (1980), which is the C aquifer of HLA (1987), was considered to lie deeper than about 200 feet bls. Data from this study indicate that a thin, but continuous sand is present at about 165 feet bls and is separated from the lower most sequence of thick sands by about five feet of clay. Geologic and hydrologic data from this study indicate that this sand can be considered part of the C, or lower aquifer.

Past over-pumping of the shallow aquifers (A and B) resulted in extensive saltwater intrusion. Less extensive saltwater intrusion has occurred in the C aquifer, though over-pumping has resulted in land subsidence in the basin. Ground water use at NAS Moffett Field is now limited to agricultural irrigation from three wells which are completed in the C aquifer. Recharge to the aquifers is primarily from infiltration on upgradient alluvial fans (where aquifers are not separated by extensive clay) and percolation of rainfall, stream flow, and excess irrigation water. Surface water runoff predominantly is pumped to a canal which runs to Guadalupe Slough and is eventually discharged there. The pumping station for this system is near Site 2, and ground water data from this area (a cone of depression) indicate that some discharge of the A aquifer also goes to the canal. The predominant discharge of aquifers, however, is assumed to be to the Bay.

Data from this study indicate that the shallow aquifers act as confined aquifers. The deeper C aquifer is confined and flowing artesian conditions

occur in some wells on the station. Ground water movement is generally northward with a gradient of about 0.004 feet/foot in the A aquifer.

25.2 RISK ASSESSMENT

The Phase I risk assessment was based on a qualitative review of the Phase I field investigation data. The results of this review were used to perform a preliminary hazard assessment for the purpose of determining if any immediate and substantial hazards exist that may require immediate or interim actions. In addition, the Phase I assessment identified any additional sampling efforts required by data gaps.

The preliminary risk assessment included the following sections:

- Identification of chemicals of concern
- Identification of migration pathways
- Identification of exposure pathways
- Hazard evaluation
- Preliminary environmental risk evaluation.

The selection of chemicals of concern follow the procedures given in the EPA Risk Assessment Guidance for Superfund, Vol 1: Human Health Evaluation Manual (EPA, 1989) (Section 24.2). A summary of chemicals of potential concern in all sampled media at NAS Moffett Field is presented in Table 24.2-9.

The purpose of the migration pathway analysis is to describe the site-specific pathways related to chemical transport that may result in potential exposure points for humans or environmental receptors. In general, the major routes of migration off site at NAS Moffett Field are via the air, surface water runoff, runoff of leachate from landfills, and leaching into ground water. The air migration pathway would be limited only to chemicals found in the surficial soils. Leaching into ground water is the other potential migration pathway for chemicals in the soils.

Potential human exposures may occur by primary pathways (e.g., dermal contact, inhalation, or by direct consumption of soil or water) or through secondary pathways involving the transfer of site-related chemicals through a food chain or web. Exposure to site-related chemicals in soils as a result of dermal contact or by inhalation of organic vapors or particulate-bound chemicals was

not considered to be a viable route of exposure. Significant exposure to these chemicals would only result from close contact with the soil. Access to sites which have elevated levels of chemicals in the soil has been restricted to authorized personnel, and all persons required to work in these areas are required to consult with the NAS Moffett Field safety officers for appropriate guidance (NAS Moffett Field, 1989). Given the policies restricting the type of activities which take place in these areas, and the institutional controls on those activities, it is unlikely that base personnel will be exposed to significant levels of site-related chemicals.

Exposure to chemicals in the ground water from either consumption or dermal contact is unlikely. Well surveys show that no known domestic wells exist that draw water from the shallow aquifer (K/J/C, 1988). Domestic water for the base is presently supplied via the San Francisco Aqueduct. It is likely that this water supply will continue to be the domestic water source in the future (WESTDIV, 1985). The shallow aquifer recharges the drainage ditch on the base perimeter, and the marsh on the northwest corner of the station. Swimming or other water sports activities do not occur due to the nature of the area. Prolonged contact of large areas of exposed skin with the waters in these areas does not appear to occur.

Analysis of the primary exposure pathways indicate that, under current and predictable future usage patterns, no direct pathways for long-term routine exposures of human receptors exist. Any potential exposures that could occur would be random and sporadic events, for which the occurrence would be unpredictable, and are not likely to be regularly repeated by the same individual receptor.

Potential secondary exposure pathways include duck hunting and fishing. Significant exposure from bioaccumulation of chemicals in ducks is unlikely because of the limited amount of duck that can be consumed in a year. However, because the water in the area is classified for use in ocean commercial and sport fishing, consumption of fish may be a viable secondary pathway. Additional information concerning the potential concentration of

site-related chemicals in the water and the amount of fish consumed that are harvested from these waters is needed to quantitatively evaluate this pathway in the Operable Units Report risk assessment.

The maximum ground water concentration of chemicals of concern were compared to the water quality criteria for the consumption of fish under the Clean Water Act (EPA, 1986). This is a very health-protective assumption because the expected dilution of the ground water by any receiving surface water body would result in surface water concentrations which are far below the concentrations in the ground water. Chemicals detected in the ground water which exceeded the water quality criteria were 1,2-dichloroethene, 1,1-dichloroethene, trichloroethene, tetrachloroethene, and carbon tetrachloride. These chemicals, and the chemicals for which ambient water quality criteria do not exist, will be quantitatively evaluated in the Operable Units Report.

Wildlife and fish may be exposed to site-related chemicals in the shallow aquifer. The animals and the birds which inhabit, or feed, in the area may use the drainage canals on the north side of NAS Moffett Field as a drinking water source and the marsh located at the northeast corner of the station may be of importance as nesting habitat to local waterfowl. These birds may be directly exposed to site-related chemicals in the marsh. Fish and other aquatic organisms which inhabit the waterways surrounding NAS Moffett Field may also be exposed to site-related chemicals which have been transported off site via the ground water.

The Clean Water Act has ambient water quality criteria for some priority pollutants. These criteria represent the maximum concentration to which aquatic organisms may be chronically exposed without adverse effect. None of the chemicals of concern identified in the ground water have water quality criteria.

Further data are required before any conclusions can be made concerning potential risks from exposure of environmental receptors to site-related chemicals. During Phase II, data will be collected to better characterize discharge of ground water into surface water at Moffett and the expected level of exposure after dilution. Species present that represent the most sensitive

and endangered species present at potential points of exposure will be identified.

The chemicals present in the environmental media at NAS Moffett Field should be quantitatively evaluated to assess potential risks to human health from the consumption of fish which have bioaccumulated site-related chemicals. This will be addressed in the Operable Units Report risk assessment. Environmental receptor populations include terrestrial mammals, birds, and freshwater and marine populations. Additional information is necessary before the potential impact of site-related chemicals on these populations can be evaluated.

25.3 SITE SPECIFIC FINDINGS AND RECOMMENDATIONS

25.3.1 Site 1 - Runway Landfill

Site 1 is the landfill at the northernmost edge of NAS Moffett Field. Adjacent features include Jagel Slough, marshland, salt evaporation (holding) ponds, and the runway. It is currently used for storage of traffic control materials and a pistol practice range.

The landfill received various waste solvents, refuse, and scrap equipment during the 1960's to 1978. Fill and cover are mounded up to 10 feet msl and, in places, fill was placed to about -13 feet msl. The landfill was never formally closed, and the cover material and thickness varies over the fill. The buried debris is a potential source of contamination to soils and ground water at the site through processes of runoff to adjacent low areas and leachate percolation to the underlying ground water system.

The Phase I investigation included deep borings around the periphery to define stratigraphy; a geophysical survey to estimate the extent of the fill; installation of monitoring wells in the fill to characterize leachate and fill, and on the periphery of the landfill in the A Aquifer to monitor for contamination; and permeability testing of native soils beneath the landfill. A Phase II investigation is not currently planned for this site, though air quality testing is required. Findings and recommendations from the Phase I investigation are summarized below.

Findings

- In the landfill, a shallow aquifer is perched above the native clay which underlies the fill. This clay separates the fill from the A aquifer. Hydraulic heads in the perched aquifer are higher than those of the A aquifer, indicating that there is a potential for leachate to migrate down to the A aquifer.
- Runoff from the mounded landfill drains into a former evaporation pond to the north of the landfill and may carry leachate with it. It may also drain to the adjacent Jagel Slough. Another possible pathway for leachate movement is via an old buried channel (interpreted from aerial photographs) which appears to extend beneath the runway and toward the adjacent marsh.
- Landfill soils contained various organic compounds, generally at different depths and locations. Few compounds were found above sample quantitation limits, and were at low levels. Of note, phthalates and phenols were found at a maximum of 27 mg/kg, PCBs were found at a maximum of 18 mg/kg, and chlorinated and aromatic hydrocarbons were found at a maximum of 0.22 mg/kg. Only carbon disulfide was found above quantitation limits in the samples taken from the native soil beneath the fill, but at levels that are considered to be naturally occurring.
- A few elements were detected above baseline concentrations in landfill materials, though most were within the ranges established by the USGS, or within the station baseline. Copper, chromium, lead, mercury, nickel, silver, and zinc were found at elevated levels in the landfill material, however, not in samples from the native soils beneath the landfill. Cobalt, vanadium, mercury, and thallium were found in one sample each from the native soil at concentrations only slightly above the baseline. The data indicate that there are elevated metals concentrations in localized areas of the landfill, but that none have migrated in significant quantities to the native soils beneath the fill.
- Analysis of leachate showed that nine VOCs occurred consistently above quantitation limits in one or more leachate monitoring wells. The hydrocarbons BTEX were found at levels of up to 660 µg/l, and three other hydrocarbons were found at up to 8,300 µg/l. Five BNAs were found consistently above quantitation limits in two wells; phenolic compounds at concentrations of up to 7,900 µg/l and naphthalene and benzoic acid at up to 11,000 µg/l. Other organic compounds were found, but did not occur consistently (in 50 percent or more of the samples from one well).
- Metal and other inorganic elements which are naturally occurring in seawater and ground water were found in high concentrations in the leachate well samples. Eleven other elements were found in wells, but only two were reported consistently at concentrations above sample quantitation limits: arsenic was found in only one well with concentrations at the site up to 34 µg/l; barium was found in two

wells with concentrations up to 6,580 µg/l. Sample quantitation limits are high due to the interferences of high total dissolved solids of the Bay water.

- Analysis of soil samples from wells surrounding the landfill (perimeter wells) indicated no contamination by VOCs and only one significant occurrence of a BNA compound. VOCs detected were commonly associated with method blank contamination, or were naturally occurring compounds. BNA compound 4-methylphenol was found in the wet season sediment sample from Jagel Slough at 1,200 µg/l. This compound was also found in landfill leachate and may indicate that runoff from the landfill in the wet season carries some leachate with it, though no other compounds found in the leachate were found in the sediment sample.
- Nearly all elements tested for were found in soil or sediment samples at concentrations above the low baselines, but typically were less than twice the station baseline and were considered a natural variation in soils. Lead occurred in one of two sediment samples from the Salt Flat area with a concentration of more than three times the station baseline, indicating there may be isolated areas of elevated lead. However, the concentration found was less than 1.5 times other local baselines, and may be a natural occurrence.
- Analysis of ground water samples from the Site 1 A-aquifer wells showed no organic compounds were detected consistently with the exception of common laboratory contaminants. These data do not show degradation of the A aquifer by organic compounds.
- A-aquifer monitoring wells had concentrations of elements common in ground water and seawater at levels typical for the station. All other elements tested for were found above quantitation limits at least one time in A-aquifer well samples, however, none were found consistently. Most of the concentrations reported are estimated due to interferences from high total dissolved solids in seawater, and the presence of significant quantities of trace elements is suspect. As reported however, the data indicate that degradation of ground water quality by inorganic chemicals is limited to the effects of saltwater intrusion.

Recommendations

Monitoring well data indicate that contamination from the landfill soils and leachate has not migrated to the surrounding soils and shallow aquifer.

However, aerial photographs and geophysical surveys indicate that a trench extended from the landfill beneath the runway extension and toward the adjacent marsh. This former trench may provide a pathway for migration of landfill contaminants, depending on the trench fill material and extent. The former trench should be further investigated to ascertain its existence and nature. If found, it should be monitored to determine if it provides a

pathway for migration of contaminants.

25.3.2 Site 2 - Golf Course Landfill

Site 2 is the landfill located just west of the golf course at the intersection of Patrol Road and Zook Road, and adjacent to a salt evaporation pond. The site is enclosed by a chain link fence on the north and west sides, and along portions of the south and east sides.

The landfill was used from the 1940s to the 1960s in a similar manner as the Site 1 landfill and may have received some of the same types of hazardous wastes (waste solvents, fuels, oils, refuse, and scrap equipment). A burn pit in the present golf course area was used for disposal of outdated flares and cartridge activated devices until 1971. The site is basically flat and open except for some mounded areas where debris is visible at the surface. The buried debris is a potential source of contamination to soils and ground water at the site through processes of runoff to adjacent drainage ditches and leachate percolation to the underlying ground water system.

The Phase I investigation included deep borings around the periphery to define stratigraphy; a geophysical survey to estimate the extent of the fill; installation of monitoring wells in the fill to characterize leachate and fill, and on the periphery of the landfill in the A aquifer to monitor for contamination; and permeability testing of native soils beneath the landfill. A Phase II investigation is not currently planned for this site, though air quality testing may be required.

Findings

- Interpretations of the geophysical survey data concluded that the landfill is located further northwest, and encompasses a smaller area than indicated by a previous study.
- Laboratory permeability test results show that permeabilities of the clay material below the fill are on the order of 10^{-8} cm/sec.

- The saturated zone in the fill is variable and represents a perched condition with potential for downward migration of moisture into the A1 subaquifer.
- There is minimal topographic relief at Site 2 and the area is graded to drain surface water flow into local drainage ditches that convey the runoff to a canal along the northern boundary of the station. The water is then pumped to a canal that eventually discharges to Guadalupe Slough.
- Organic analysis of landfill soils showed only minimal organic contaminants at concentrations above quantitation limits. One sample from W2-11(F) contained a low level of benzo(b) fluoranthene. PCBs were found in three soil samples with a maximum concentration of 28,000 ug/kg. Analysis did not show other organic contamination in landfill soils, or in the native soils from beneath the fill.
- Analysis of soil samples from periphery borings showed only low level xylenes in one sample from a boring upgradient of the landfill. Other organic contaminants were below quantitation limits, associated with laboratory blank contamination, or were not confirmed by duplicate analysis.
- Inorganic analysis of soil samples showed that most inorganics are present within typical ranges for local soils, or at levels only slightly elevated above baselines. However, arsenic was found at a concentration that was about four times the baseline in a soil sample from the 3-foot depth of a periphery well boring. Five inorganic constituents were found at levels significantly elevated above baselines. All of these constituents, arsenic, barium, cadmium, copper, and zinc, were found in one sample from the 3-foot depth of well boring [W2-6(A)]. The upper portion of this boring was drilled through fill. However, because other soil samples from intervals described on logs as containing fill material did not contain similar concentrations of these metals, it would be prudent to review the analytical data reduction calculations.
- Organic analyses of ground water and leachate samples showed only limited contaminants are present in the landfill leachate, but not in the A aquifer. Napthalene was found in leachate well samples at concentrations ranging from 12 to 50 ug/l, and single detections of chlorinated VOCs and volatile fuel components were found at levels of up to 42 ug/l. Multiple rounds of sampling did not show contamination of the periphery A aquifer wells.
- Inorganic analysis of ground water and leachate samples did not show degradation of water quality other than that due to saltwater intrusion.
- Samples of surface water adjacent to the landfill did not show water quality degradation by organic or inorganic constituents.
- Analysis of sediment samples from the adjacent Jagel Slough did not show evidence of contamination by organic or inorganic constituents.

Recommendations

A Phase II investigation is not planned for Site 2. The results of the Phase I investigation indicate that any additional investigation required could be conducted as part of any remedial measures implemented at the site.

25.3.3 Site 3 - Marriage Road Ditch

Site 3 is the ditch that runs northward along Marriage Road from Macon Road to the facility perimeter ditch. Water is pumped from the ditch to the perimeter canal that carries discharge water to Guadalupe Slough. Marriage Road Ditch was constructed prior to 1947 and is mostly unlined, though some portions are lined with concrete. It originally extended to the Hangar 2 and 3 apron and received discharge from storm drains there. Wastes disposed of via the drains and ditch from the 1940s to the 1970s contained waste oils, solvents, fuels, detergents, paints, and hydraulic fluids. A plume of VOCs which is believed to originate at Site 7 encroaches the Site 3 area in the A aquifer.

Underground storage tank No. 53 was formerly located near the northern end of Marriage Road Ditch and provided 500-gallon capacity storage of unleaded gasoline for the golf course physical plant. Because this tank was determined to have leaked, it was removed, and further investigation and any remedial action will be performed as part of Site 19.

The Phase I investigation included deep borings to define stratigraphy; installation of monitoring wells to monitor the encroachment of the upgradient plume and any contamination emanating from the ditch; shallow soil, sediment, and surface water sampling along the ditch to characterize the potential source; and a soil gas survey on the golf course to assess the extent of the Site 7 plume. A Phase II investigation has been initiated at this site. Findings and recommendations based on the Phase I data are summarized below.

Findings

- The geology and hydrogeology of Site 3 is not significantly different from that described in Section 25.1. The A1 subaquifer appears to be less continuous than it is on the west side of the base, and the uppermost section has more clay.

- Analyses of shallow soil samples from along the ditch and well boring soil samples indicate that significant soil contamination is restricted to the shallow soils along the ditch. Low levels of TPHC and PCBs were found in ditch samples. Phthalates were found in scattered well boring samples, but the highest concentrations (up to 41,000 ug/kg) were found in ditch samples. Phthalates are found at variable levels in most places on the station, however, so it is uncertain if these phthalates are from a local source. The source of PCBs in the ditch samples is also unknown.
- Trace metals were found at elevated levels in soil samples collected from the ditch or from well borings adjacent to the ditch. Elements found above baselines include barium, beryllium, chromium, lead, cobalt, copper, nickel, and zinc. Most of the elevated levels were in samples from less than three-foot depths indicating localized contamination along the ditch.
- Results of the soil-gas survey indicate that the shallow ground water plume from Site 7 does not extend as far as was postulated in previous investigations (ESA, 1986a). Three small isolated areas of high soil-gas concentrations (up to 1923.5 ppm total ionizable compounds) were found in the northeastern part of the golf course. These areas were previously unidentified as potential contamination areas and they are remote from any known potential source.
- Significant contamination by organics in ground water was found only in an A1-aquifer well adjacent to, and at the southernmost end of, Marriage Road Ditch. This well had low levels of four chlorinated VOCs (15 ug/l of TCE, maximum). These compounds likely represent the downgradient fringe of the A1-aquifer Site 7 plume. No other organics were found consistently, or at significant levels, in any other Site 3 wells, indicating that the ditch is not contributing contaminants to the ground water at significant levels.
- Elements common to ground water and saltwater were found in the A, B, and C aquifers at levels typical of the station. Trace elements were not found consistently or above quantitation limits in any Site 3 monitoring wells, although detection limits were often elevated due to interferences of high TDS of saltwater. Similar to the organic water data, the inorganic data, as reported, indicate that there is no degradation of ground water quality by contaminants from the ditch or upgradient plume.

Recommendations

Because soil contamination in and along the ditch appears to be limited to shallow soils, no further investigation is recommended for this area.

Additional soil sampling that may be necessary can be performed concurrently with remedial measure implementation. A Phase II investigation has been initiated at Site 3 that includes installation of monitoring wells near the ditch to supplement monitoring of the Site 7 ground water plume, and soil

borings and monitoring wells to investigate the isolated soil-gas "hot spots." The need for investigation beyond Phase II is not apparent at this time, though this will be determined by the results of the Phase II investigation.

25.3.4 Site 4 - Abandoned Wastewater Holding Pond

Site 4 encompasses the former industrial wastewater holding pond that was located north of Hangar 3 and west of the existing ponds. The former pond received waste and wastewater from activities at Hangars 2 and 3 from 1968 to 1978. Hazardous materials disposed of as waste or in wastewater included fuels and oils, paint sludge and stripper, solvents, chlorinated VOCs, and ethylene glycol. Wastewater was held in the unlined pond, and then treated and discharged to the sanitary sewer.

The Phase I investigation included deep borings to define stratigraphy, and installation and sampling of monitoring wells to assess contamination in the A, B, and C aquifers. A Phase II investigation has been initiated at this site. The conclusions and recommendations from the Phase I investigation are summarized below.

Findings

- The geology and hydrogeology of Site 4 is mostly consistent with the regional geology. Coarse sediments in the A aquifer zone are discontinuous and, in some areas, are absent altogether.
- Results of soil sample analysis showed that very low levels of chloroethane and toluene were found, and in only one sample each. These findings are not indicative of significant contamination.
- Inorganic analyses of soil samples found one unusually high concentration of iron. The reason for this occurrence is not clear. Other common and trace elements were at concentrations typical of the station soils with local variations considered to be natural.
- Analysis of ground water samples showed that low to moderate levels of chlorinated VOCs (e.g., up to 51 ug/l TCE and 490 ug/l 1,2-DCE) are present in the A1 and A2 subaquifers. These contaminants are suspected to be representative of the ground water plume emanating from Site 7. Data indicate that there is no contamination to the B3 or C aquifers at this site.

- Inorganic analyses of ground water samples from the Site 4 Phase I investigation included B and C aquifer wells only. The data indicated no degradation to ground water quality by inorganic contaminants, other than that known to be a result of saltwater intrusion.

Recommendations

A Phase II investigation has been initiated at Site 4 to evaluate areas more proximal to the potential sources there (e.g., Tanks 16 and 17, and the former pond). Data from the Phase II investigation will determine the completeness of the information needed to characterize Site 4 sources and contamination at the site from upgradient sources. Investigation beyond Phase II cannot be anticipated at this time.

25.3.5 Site 5 - Fuel Farm Area

Site 5 was the location of the main fuel facilities for NAS Moffett Field for about 15 years in the 1950s and 1960s. The site lies between the Hangar 3 runway aprons and the eastern most segment of Patrol or Macon Road. Fuel storage facilities included several above ground tanks, and underground waste oil and fuel tanks. Stored fuels included diesel, jet fuel, and unleaded gasoline. In two locations, above ground tanks were surrounded by french drains. Wastewater and fuel were pumped into the french drains during routine tank drainage. The exact locations of the drains and the quantities of fuels discharged to them are not known.

The IAS (NEESA, 1984) estimated that as much as 28,000 gallons of fuel could be present above the water based on observations of fuel levels in wells. Soil samples showed fuel components, including organic lead. A subsequent investigation found highly variable occurrences of organic priority pollutants such that an organic plume was not defined. Alkanes were the predominant compound found with concentrations up to 200 ug/l in two wells.

The Phase I investigation at Site 5 included deep borings to characterize the stratigraphy; installation of monitoring wells in the A, B, and C aquifers; soil-gas sampling to assess potential ground water plumes and soil contamination; and soil and ground water sampling. A Phase II investigation has been initiated at Site 5. Findings and recommendations based on the Phase I investigation are summarized below.

Findings

- The geology of Site 5 is consistent with the regional geology described earlier. A significant variation at this site is the lack of coarse grained or aquifer material in the A aquifer zone in the northern area. The predominance of clay material may have significantly restricted migration of spilled fuels to the aquifers beneath this site. Another variation near the central area of the site is the occurrence of the A1/A2 aquitard. This aquitard is not strongly evidenced in boring and geophysical logs in the expected depth interval; however, a fairly well developed clay occurs within the A aquifer zone about 10 to 15 feet lower than that. This stratigraphy may allow more local interconnection between the A1 and A2 subaquifers than is expected in areas where the A1/A2 aquitard is continuous.
- Analysis of soil samples showed indications of fuel contamination (TPHC up to 1,000 mg/kg) at only one location, which was downgradient of Tanks 8 and 9.
- Inorganic analyses of soil samples showed element concentrations to be within baselines or at levels considered to be natural variations with one exception. One sample collected from near the above ground fuel farm in the northern Site 5 area had elevated concentrations of lead. This may be a result of leaded fuel contamination, though no fuel components were found in this sample.
- Soil gas concentrations were elevated in four areas at Site 5. Three were near the above ground fuel tanks in the northern area where there was a known spill of about 2,000 gallons. Soil gas in this area was predominantly composed of fuel constituents. A fourth area of elevated soil gas was found east of Site 5 where soil or ground water contamination was previously unsuspected. Soil gas here was composed predominantly of chlorinated VOCs and may indicate dumping of cleaning solvents used in area operations.
- Analysis of ground water samples from the A and C aquifer wells did not show consistent detections of organic contaminants, with the exception of the common laboratory contaminants. Low to moderate level detections of TPHC and fuel components were found in few A1 subaquifer wells, however these detections were inconsistent (less than 50 percent of samples from a well) and are not considered indicative of ground water contamination.
- Inorganic analysis of ground water samples showed concentrations of common saltwater and ground water constituents at typical station levels. Only one of the tested trace elements showed consistent detections above quantitation limits. Selenium was found in one A2-subaquifer well at concentrations below the area background levels reported by the Department of Water Resources.

Recommendations

A Phase II investigation is planned for the Site 5 area which includes soil borings and monitoring wells close to tanks as well as in the far field, and in areas of high soil-gas concentrations. Free product wells are planned near particular tanks, and augers will be used to probe for french drains. The need for additional investigation will be determined by the results of the Phase II investigation.

25.3.6 Site 6 - Runway Apron

Site 6 is the runway apron area adjacent to the Hangar 3 apron and south of the Site 4 ponds. The area was used for casual disposal of wastes from aircraft maintenance, including solvents, fuels and oils, and paints, from the 1940s to the 1970s. In 1979, the Hangar 3 aprons were enlarged by paving over this area. Upgradient and adjacent areas of potential contamination include Sites 5, 7, and 13.

The Phase I investigation at Site 6 was limited to sampling ground water from two A1-subaquifer wells which were installed in a previous investigation. Analysis included organic compounds and major ions.

A Phase II investigation has been initiated at Site 6. This investigation will examine the potential contribution to ground water from upgradient sources as well as the potential contribution from Site 6 activities.

Findings

- Analysis of ground water samples showed low levels (less than 10 ug/l) of chlorinated VOCs. Only 1,1-DCA was found consistently in one well. The very low levels detected appear to be from the fringe of the Site 7 plume, rather than related to Site 6 activities.

Recommendations

The Phase II investigation will provide more information on potential contamination resulting from Site 6 activities, as well as from upgradient sources. The data gathered will determine the need for additional investigation at this site.

25.3.7 Site 7 - Hangars 2 and 3

Site 7 consists of Hangars 2 and 3 and the paved area surrounding the hangars. Unpaved areas at the corners of the hangars were used to discard wastes such as paints, solvents, fuels and oils, and hydraulic fluids. From the 1940s to the late 1970s, waste and wastewater accumulated in unpaved areas surrounding the hangars and flowed through deck drains to Marriage Road Ditch (Site 3). Several large fuel tanks and a steam cleaning waste sump were located at the northeast corner and on the east side of Hangar 3. These tanks (Tanks 2 and 43) had leaked and were removed and investigated as Site 19. Previous investigations concluded that a plume of VOCs in ground water is emanating from the tank at the northeast corner of Hangar 3.

The Phase I investigation included deep borings to define stratigraphy, installation of monitoring wells in the A and C aquifers, and soil borings at the corners of Hangars 2 and 3. A Phase II investigation is planned for Site 7 that includes additional monitoring well installation and ground water sampling.

Findings

- The geology at Site 7 is consistent with the station geology.
- Results of soil sample analysis showed relatively minor amounts of contamination by organic compounds. Two samples showed TPHC contamination (up to 160 mg/kg) and two showed low levels of total xylenes (up to 16 ug/kg). These samples were taken from borings near Tank 2 and at the southern corners of Hangar 3.
- Inorganic analysis of soil samples indicated that most elements occur at concentrations typical of the station soils. Samples from the southeast corner of Hangar 2, however, showed elevated levels of copper (up to 20,000 mg/kg) and zinc (up to 8,660 mg/kg), with the highest levels at the 1 foot depth. These data suggest there is local contamination; possibly from dumping of wastes containing brass shavings associated with hangar operations.
- Analysis of ground water samples from A and C aquifer wells indicate that significant degradation of ground water quality by organics is probably limited to the Tank 43 leak at the northeastern corner of Hangar 3. Monitoring well coverage for the A1 subaquifer is limited near Tank 2. Supplemental information specific to this tank is discussed in Site 19.

- Inorganic analyses of ground water samples indicates that degradation of ground water quality is primarily limited to saltwater intrusion typical of the station ground water. Selenium was found at low levels (up to 7.8 ug/l) in one A2-subaquifer well at Site 7. Similar to Site 5, the element occurs at levels below regional background level reported by the DWR.

Recommendations

The Phase II investigation currently planned for Site 7 will help determine the need for additional investigation there. Additionally, tank removals have been conducted by the Navy and will provide needed information on the extent of soil contamination surrounding known leaking tanks within the Site 7 area. As the local area of high metal concentrations at the corner of Hangar 2 is now covered by concrete, and there is no indication of ground water contamination by these metals, investigation beyond Phase II is not recommended for this location.

25.3.8 Site 8 Waste Oil Transfer Area

Site 8 is the waste oil transfer area and storage yard next to Building 127, between Zook Road and McCord Avenue. From the 1940s to the 1980s, a 5,000-gallon tank at the site received waste oil from the facility which reportedly included about 100 gallons per year of transformer oils (possibly containing PCBs) and about 200 gallons per year of solvents. Oil was transferred from trucks into a sump next to the road and then to the tank, and was reportedly spilled onto the ground during transfer from the trucks. Both the tank and sump were removed in 1981.

The storage yard includes about 20,000 square yards of gravel covered lot which currently serves as a storage yard for obsolete vehicles and other equipment. Vehicles and equipment stored in the yard may have leaked petroleum products (fuels, oils, hydraulic fluids) to the shallow soils.

The site is downgradient from several potential sources: the NAS Ames research facility is immediately upgradient and has known tank leakage of fuels and solvents; the Navy Site 9 has fuel and solvent sources; and the far upgradient MEW companies have solvent sources that have been reported to have contributed to a ground water contaminant plume as far as the Site 8 area.

The Phase I investigation at Site 8 included deep borings and geophysical logging to characterize the stratigraphy; shallow soil borings to identify shallow soil contamination near the sump and in the yard; and installation of A- and C-aquifer wells to monitor both upgradient sources and contamination that may have resulted from Site 8 activities. Ground water monitoring included the Phase I wells and previously installed A and B-aquifer wells. A Phase II investigation is currently underway to further define contamination that may have resulted from Site 8 activities.

Findings

- The geology and hydrogeology at Site 8 is typical of the station geology. Site 8 is toward the northern end of the station and thus the stratigraphic section is composed predominantly of deposits of the open bay/distal end of the estuarine system. This results in better defined clay and sand units.
- Results of soil sample analysis indicates minimal contamination to soils has occurred. A total of seven samples contained organics above quantitation limits. These included only two with TPHC at a maximum of 380 mg/kg near the sump, and one with benzoic acid at 2,000 mg/kg. Other samples had the common phthalate bis(2-ethylhexyl)phthalate and trace amounts of toluene. Samples with fuel related contamination were from the 1-foot depth, indicating that soil contamination at the site is localized and shallow. While a previous investigation found PCBs in a soil sample adjacent to the sump, PCBs were not found in the Phase I samples.
- Inorganic analysis of soil samples showed most elements at levels typical of the station. One boring location (SB 08-01) showed high concentrations of copper and zinc down to the 3-foot level (copper up to 21,600 mg/kg and zinc up to 8,710 mg/kg). Another location showed lead at elevated levels in the 3-foot depth sample (61.6 mg/kg). These elevated concentrations appear to be localized.
- Ground water monitoring data showed A-aquifer wells contained low level chlorinated VOCs (e.g., up to 10 ug/l TCE, and 70 ug/l 1,1,1-TCA). Insufficient data are available to determine a source for this contamination, though of note is the absence of fuel components and TPHC. This finding is not unexpected in light of the limited soil contamination found. Organic compounds were not detected consistently in B- or C-aquifer wells.
- Inorganic analysis of ground water samples showed levels of elements common to saltwater and ground water typical of the station. Only the trace element arsenic was found consistently at levels above

background. This was found in the C well only. The reason for its occurrence there and not in the shallower aquifers is unclear, but does not indicate a local source.

Recommendations

A Phase II investigation has been initiated at Site 8. Additional monitoring wells and soil samples are part of the investigation plan. These wells and borings will determine the need for more investigation to determine the source and extent of VOC contamination in the A aquifer. It is expected that further delineation of soil contamination could be accomplished as part of any remedial measure implemented at this site.

25.3.9 Site 9 - Old Fuel Farm

Site 9 includes several areas of potential sources within a three square block area immediately west of Hangar 1. Two of the source areas, the Old Fuel Farm and the Old NEX Station, consist of underground fuel storage tanks, some of which were reported to have leaked. Fuels stored in Site 9 tanks from the 1940s to the 1960s included aviation gas and motor vehicle gas. Also within the Site 9 area is the Public Work's Paint Shop Sump (Site 17), and on the upgradient border of the site is the Dry Cleaner's Sump (Site 18).

Additionally, several upgradient sources have contributed, or have had potential to contribute, contaminants to the ground water beneath Site 9. A solvent plume in the A aquifer has been mapped to extend from the MEW area across Highway One to the north end of Site 9 (HLA, 1987). Potential upgradient sources include the Site 14 former fuel tanks, the operating NEX station, and seven other sumps, tanks, or abandoned tanks used for fuel storage or separation/recovery of fuel and water.

The Phase I investigation at Site 9 included deep borings to characterize the stratigraphy; installation of monitoring wells in the A, B and C aquifers and associated soil and ground water sampling to assess contamination to the area; and a soil-gas survey to identify areas of soil or ground water contamination for placement of Phase II wells. A Phase II investigation has been initiated at the site to follow up on the findings of this study.

Findings

- The stratigraphy and hydrogeology of Site 9 is typical of the station. The sedimentary section indicates that the predominant depositional environment was estuarine with associated interbedded thin sands and clays. The A aquifer at this site acts as a confined aquifer, which is typical at NAS Moffett Field.
- Analysis of soil samples showed a total of nine VOCs at low levels in a scattered distribution over the site. The compounds found included chlorinated VOCs (TCE at up to 43 ug/kg and 1,1,2,2-PCA up to 420 ug/kg) and fuel components (toluene at up to 37 ug/kg). The PCA was found in two well borings near the Old Fuel Farm. None of the well borings were placed immediately downgradient of tanks and thus the data collected are insufficient to positively identify sources at Site 9, though some data point to assumed sources such as the Dry Cleaner's sump.
- Inorganic analysis of soil samples showed concentrations of elements at levels typical of the station soils with few exceptions. Copper was found in one sample from the 5-foot depth at 287 mg/kg, about five times the station baseline, and lead was found at the 1-foot depth from another boring at 60.2 mg/kg, about three times the station baseline. The reason for the isolated occurrences of these metals is not clear, though they do not appear to be indicative of anthropogenic sources.
- The soil-gas survey found elevated concentrations of soil gas in the four areas of suspected sources (the Old Fuel Farm, the Old NEX Station, Site 17, and Site 18) and in five areas which were not previously identified as potential sources. GC analysis of soil-gas samples showed that the vapors contained chlorinated VOCs and fuel compounds in nearly all areas of Site 9. However, the highest concentrations of chlorinated VOCs were near the Dry Cleaner's sump, and the highest levels of fuel compounds were near the Old Fuel Farm and the Old NEX Station. These data indicate that the main source areas at Site 9 are probably those identified by the IAS.
- Ground water samples from most A-aquifer wells showed consistent detections of the chlorinated VOCs 1,1,1-TCA (88 ug/l maximum); 1,1-DCA (66 ug/l maximum); 1,1-DCE (87 ug/l maximum), and 1,2-DCE (total, 900 ug/l maximum). TCE was found in eight of 11 A-aquifer wells with the highest concentrations (36,000 ug/l) in an A2-subaquifer well downgradient of the Dry Cleaner's sump (no A1-subaquifer well is in this immediate area). The data collected are insufficient to distinguish Site 9 sources from any regional contamination which may have resulted from upgradient sources. Data from the B- and C-aquifer wells showed only sporadic, trace levels of organic compounds that were not indicative of ground water contamination.
- Inorganic analyses of ground water samples showed levels of common metals and trace elements typical of the station ground water in the three aquifers. Selenium was found in two adjacent A1-and A2-

subaquifer wells at low levels (up to 14.1 ug/l), which were within the background levels reported for the region by the DWR. Arsenic was reported consistently in one B2-subaquifer well at up to 15.3 ug/l. The low level occurrence of arsenic in this B2-subaquifer well is not understood as it is not in shallower aquifers, and is not in upgradient B2 wells. Similar unusual occurrences of arsenic were noted in the Site 8 C-aquifer well.

Recommendations

A Phase II investigation has been initiated at Site 9 that is targeted at local source identification. The investigation plan includes monitoring wells in the A and B aquifers, and shallow soil sampling. Tanks at the Old NEX Station (Tanks 56A through D) are scheduled for possible removal. The results of the Phase II investigations will determine the need for more information.

25.3.10 Site 10 - Chase Park Area and Runways

Site 10 encompasses the runway and the tanks and sumps in the area southwest of the runway and north of the Bayshore Freeway (Highway One). The area referred to as Chase Park is immediately east of the park proper and includes Tanks 19, 20, 21, 57, 58, and Sumps 58 and 60. South of Hangar 1 is the northern Site 10 area which includes Tanks 33 through 41, 51, 52, 67, 68, and Sumps 25, 42, and 66. Site 10 tanks and sumps were used for storage, separation, or disposal of petroleum products or solvents. Many of these tanks and sumps are designated as separate sites (Sites 14, 15, 16, and 18). The tanks and sumps that are considered only as Site 10 include Tank 21 - a fuel storage tank southeast of Site 14; Tank 57 - a motor oil storage tank southwest of Site 14; Tanks 33 through 41 - fuel tanks at the NEX Station south of Hangar 1; Tank 51 - a reported kerosene storage tank south of the NEX Station; and Tank 52 - a tank for storage of unknown materials also reported to be south of the NEX Station. In June of 1990, the Navy removed Tank 67 and Sump 66, and Tank 68 was closed in place. The existence of Tanks 51 and 52 was based on conversation with long-term NAS Moffett Field employees, however, research by ERM West (including a site walk, review of aerial photos, and Public Work's records) found no evidence of the tanks.

The Phase I investigation at Site 10 focused on the runway area west of Hangar 2. Monitoring wells installed here in a previous investigation showed low level concentrations of chloroform (0.1 to 6.7 ug/l) in the A and B

aquifers. The Phase I investigation included deep borings to characterize the stratigraphy; installation of an A1-subaquifer well, and sampling of this and previously installed A1-, A2-, and B2-subaquifer wells in the runway area; and installation of one C-aquifer well near the southernmost end of NAS Moffett Field to monitor background water quality. A Phase II investigation is not planned for this site.

Findings

- Site 10 encompasses a large area of the southern half of the station. The geology and hydrology are not different than that described earlier.
- Analysis of soil samples showed TPHC (370 mg/kg) at the 3-foot depth from well boring W 10-6 (C). Other organic compounds reported in soil samples were interpreted to be associated with laboratory or sampling procedures.
- Inorganic analytes were found in soil samples at levels either below the station baseline or only slightly above it, and were not considered indicative of contamination.
- Analysis of ground water samples did not show consistent indication of any ground water contamination by organic compounds or metal to nonmetal elements in A-, B-, or C-aquifer wells.

Recommendations

A Phase II investigation is not planned for the Site 10 area. Investigation at Site 9 downgradient of Tanks 33 through 41 may provide information needed to determine if these tanks require additional investigation within this project. The status of any current monitoring of underground storage tanks as part of the NEX Station operations is not known. Historical data for Tanks 21 and 57 should be reviewed and an investigation planned, as necessary. Other tanks and sumps are to be investigated as part of other sites.

To assess findings (TPHC) in well boring W 10-6(C) (TPHC), analysis for VOCs and TPHC should be conducted on samples from three borings placed within 10 feet of W 10-6(C). This sampling should determine if significant soil contamination is present at this location.

Finally, the established "Site 10" should be limited to the runway area, and

tanks and sumps should be included in the sites which encompass them geographically, as follows:

Site 14 - Tanks 19, 20, 21, 57, and Sump 58, all within 600 feet of Building 544

Site 15 (south) - Tanks 33-41, and Sumps 25 and 42, all near the NEX station

Site 16 - Sump 60 (current site definition)

Site 18 - Sump 66 (current site definition), and Tanks 67 and 68 located at the back of the Dry Cleaner's building.

25.3.11 Site 11 - Engine Test Area

Site 11 is the Engine Test Area, which lies just north of Site 2 between the runway and Devil's Slough. The site has been used to test aircraft engines under power for an unknown period of the facility's history. The test area is covered by concrete and asphalt, and has a small drainage depression that funnels waste oils, hydraulic fluids, and fuels to the southern edge of the pad. Stained soils adjacent to the pad may be a result of this drainage.

Samples collected from the stained area by the CRWQCB showed 570 mg/kg of lead, 250 mg/kg zinc, and from 20 to 50 mg/kg of cadmium, copper, chromium, and nickel. These findings prompted the Phase I investigation.

The Phase I investigation at Site 11 included installation of A-aquifer wells to assess potential contamination to ground water, and shallow borings and surface soil sampling to assess soil contamination in the surface stained area. Deep borings for stratigraphic characterization were drilled at the adjacent Site 2 and nearby Site 1. A Phase II investigation is not planned for Site 11.

Findings

- The geology of Site 11 is similar to other sites at the northern end of the station. Ground water at Site 11 is affected by pumping at the culvert pumping station south of Site 11 by Site 2, and unlike other sites, ground water at Site 11 flows to the south.
- Levels of copper, chromium, and nickel found in samples collected by the CRWQCB are within NAS Moffett Field baselines.
- Analysis of soil samples showed contamination to be in soils in the stained area by oil and grease. Oil and grease was found at up to 9,600 mg/kg at the 1-foot depth and up to 530 mg/kg at the 5-foot depth. Low levels of oil and grease (less than 50 mg/kg) were found in soil borings around the perimeter of the engine test pad, though one sample had a concentration of 560 mg/kg. Other petroleum related compounds were found in three borings above the 3-foot depth at concentrations up to 1,900 ug/kg (fluoranthene). Bis(2 ethylhexyl)phthalate was found in three samples at less than 1,000 ug/kg, and one sample showed trace amounts of 1,1,1-TCA (16 ug/kg).
- Inorganic analysis of soil samples showed elevated levels of arsenic (up to 25.2 mg/kg), barium (up to 1,470 mg/kg), and lead (up to 126 mg/kg) in and near the stained area. Copper and vanadium were slightly elevated above baselines and may be representative of the natural variation of soil composition. Ground water did not show contamination of the Site 11 A-aquifer wells by organic compounds.
- Inorganic analysis of ground water samples showed trace elements above quantitation limits, though none were found consistently in either of the wells, and most were single occurrences. These data are not indicative of ground water contamination by inorganic analytes.

Recommendations

The Phase I investigation revealed that ground water at Site 11 flows to the south, however, monitoring wells were placed based on presumed regional gradients. Because the soils at the site are contaminated by oil and grease, additional monitoring well data is needed downgradient of the contaminated area. Also, because perimeter soil borings showed low levels of soil contamination, additional soil sample information is needed to determine the lateral extent of contamination. The extent of soil sampling will be dependent on the ARARS determined for the site.

25.3.12 Site 12 - Fire Training Area

Site 12 is the fire fighting training area adjacent to the northwest edge of the NAS Moffett Field runway, north of Hangar 1. The site consists of a

bermed pit containing a mockup of a plane and a 500-gallon above ground fuel tank located north of the pit. From the 1950s to 1987, the target plane was periodically covered with waste fuel from the tank (JP-4, JP-5, diesel, and some waste solvents) and ignited. Fire crews extinguished the flames with water and or fire fighting chemicals containing bromochlorodifluoromethane, potassium bicarbonate, and other foam forming chemicals.

Residue from the burned fuels and fire fighting chemicals remains in the pit and may be leached to the ground water. Until 1980, when the practice of pumping fluids remaining after a training exercise back to the tank, was initiated, occasional overflow during the rainy season reportedly resulted in an estimated 300 gallons per year of discharge to the surrounding ground surface. Results of soil analysis in a previous investigation showed TPHC concentrations up to 2,200 mg/kg in soils north of the fuel storage tank.

The Phase I investigation at Site 12 included installation of three A-aquifer monitoring wells to assess contamination to the shallow ground water; shallow soil sampling to assess soil contamination near the tank and surrounding the bermed area; and soil gas-sampling to estimate the extent of contamination to soil and ground water. A Phase II investigation is not planned for this area.

Findings

- No deep borings were installed at Site 12; the stratigraphy is assumed to be similar to that of nearby Sites 8 and 9. The hydrology of the shallow aquifer is typical of the station.
- Organic analysis of soil samples showed toluene and xylenes at low levels (up to 30 ug/kg) in some samples from above 3 feet bls. Two soil borings showed up to 14 BNAs with concentrations of up to 3,700 ug/kg (benzo(k)fluoranthene). Relatively few samples, showed oil and grease (five samples, up to 16,000 mg/kg) or TPHC (three samples up to 1,400 mg/kg). Organic compounds were scattered at Site 12, though the predominant contamination was around the fuel tank area rather than the fire fighting training pit.
- Inorganic analysis of soil samples showed that most metal to nonmetal elements were not present in concentrations indicative of contamination. A 3- and 5-foot depth sample showed each high concentrations of copper (6,010 and 11,800 mg/kg) and zinc (2,590 and 4,880 mg/kg). Silver was found in the same 3-foot sample at 118 mg/kg. Aluminum was found in one sample at high concentrations (166,000 mg/kg). The occurrences of elevated metals appear to be in small isolated areas.

- Results of the soil-gas survey showed one location (between the tank and the training area) with a significantly elevated soil-gas concentration. GC analysis of samples showed chlorinated VOCs generally in higher concentrations than the fuel components. VOCs were present in samples surrounding the tank and training area.
- Organic and inorganic analyses of ground water samples from the Site 12 A-aquifer wells do not show degradation of ground water quality other than that regional saltwater intrusion.

Recommendations

A Phase II investigation is not planned for this site, however, additional Navy investigation is currently planned aside from the RI. The planned investigation includes soil sampling and installation of additional wells that are needed to confirm ground water quality closer to the tanks and downgradient of far field borings with oil and grease contamination. The results of this investigation will determine the need for further investigation.

25.3.13 Site 13 - Equipment Parking Area

Site 13 is a concrete/asphalt lot between the east side of Building 142 and Macon Road, immediately upgradient of Site 6. The lot is used for support vehicle parking and the building is used for repair and maintenance of the support equipment. Waste and industrial wastewater from spills, leaks, and equipment washing were flused into a surface drainage ditch adjacent to the parking area. The ditch flows into a main north-south storm drain. A sump is present on the southwest corner of Building 142 which received stripping/vehicle steam cleaning wastes.

The Phase I investigation at Site 13 consisted of sampling and analysis of four shallow soil borings along the drainage ditch.

Findings

- The geology and hydrology of Site 13 are assumed to be similar to those of the nearby Sites 5 and 7.
- Analytical results of soil samples showed that the significant contaminant was oil and grease, which was found in all samples at concentrations ranging from 6 mg/kg to 1,150 mg/kg. In general, higher concentrations were found in the 5-foot depth samples.

- Inorganic analysis of soil samples showed several metal to nonmetal element concentrations elevated to levels above NAS baselines. These were not greatly elevated however, and are considered to be within the natural variation of soil composition. Lead was elevated above baseline in half the samples collected, with concentrations up to 462 mg/kg at the 1-foot level and up to 115 mg/kg at the 5-foot level. These concentrations suggest that lead contamination is present in the ditch soils.

Recommendations

A Phase II investigation is not planned for this site; however, monitoring wells will be placed about 100 feet downgradient of Site 13 and upgradient of Sump 63 as part of the Site 6 investigation. Because higher concentrations of oil and grease were found in the bottom samples of borings in the ditch, additional sampling should be conducted in and around the ditch to define the extent of this contamination.

25.3.14 Site 14 - Abandoned Tanks 19, 20, 67, and 68

Three tanks were removed at Site 14 and one remains abandoned in place. Former Tanks 19 and 20 were located at the corner of Macon Road and the South Gate exit. Tank 67 which contained fuel or heating oil was removed from the east side of the Dry Cleaner's building (Site 18). Tank 68 was abandoned in place at this same location. No information on the use of Tank 68 is available. A previous investigation showed chlorinated VOCs in soils and ground water next to the tank; however, it is uncertain if this contamination is from Tank 68 or the nearby Dry Cleaner's Sump. In the Tanks 19 and 20 area, the previous investigation showed contamination of ground water and saturated soils by petroleum components (BTEX and TPHC).

The Phase I investigation was limited to the former Tanks 19 and 20 area. Investigation activities included deep borings to characterized the stratigraphy; soil borings and installation of monitoring wells in the A aquifer to assess contamination; and a soil-gas survey to estimate the extent of any ground water plume associated with the site.

Findings

- The geology of Site 14 (Tanks 19 and 20) is similar to that described for the station. It is notable that at this southern end of the station, the shallow section has features which indicate deposition by fluvial processes, though the dominant depositional environment still appears to be estuarine. The hydrology is typical of the station.
- Soil samples collected from above the saturated zone showed little indication of fuel contamination and only a trace of 1,1,1-TCA in one sample (3-foot depth, 8 ug/kg). Organics detected were common laboratory contaminants, possibly including a few low level detections of 2-butanone and toluene. The data indicate that any soil contamination resulting from the tanks is limited in extent in the shallow soils.

- Many metal to nonmetal elements in soils were above baselines. Most occurrences were sporadically distributed and concentrations were not significantly elevated above baselines such that they would be considered out of the range of natural variation of soil composition. However, three elements were significantly elevated above baselines. Arsenic occurred above baselines in six samples from the 3- and 5-foot depths with concentrations of up to 269 mg/kg. Barium was found up to 646 mg/kg, mostly from samples at 5-feet bls or greater. Selenium was found in three samples above baseline at up to 7.2 mg/kg. The source of these elements is unknown.
- Organic analysis of ground water samples showed chlorinated Vocs in A 2-subaquifer wells at the western end of the site and in the western most far field MEW wells. Concentrations were low to moderate (TCE up to 170 ug/l). Fuel components were found only in one A1-subaquifer well that is cross gradient from the former tank locations. Benzene was found at levels up to 2,800 ug/l in this well. The downgradient A1 and A2 wells did not show fuel contamination, indicating that any fuel plume has not migrated far from the source. The division of contaminants; only fuels in the uppermost aquifer (A1) and only chlorinated solvents in the A2 subaquifer, indicates that the fuel contamination is from the former tanks and that the solvent compounds are from the regional (MEW) plume.
- Inorganic analysis showed that three elements were detected consistently and in one to three A1 subaquifer wells. Arsenic was found at elevated levels in one well, and iron and manganese were found in three wells. Levels of iron and manganese in A2-subaquifer wells were above the DWR background, but were at levels typical of NAS Moffett Field. The source of these three elements in the A1-subaquifer is not known, though arsenic was found at elevated concentrations in soils.

Recommendations

A Phase II investigation is not planned for Site 14; however, additional investigation is planned by the Navy aside from the RI. Because investigations to date have not sampled the unsaturated soils which lie below the former tank bottoms (presumably greater than 5 feet bls), additional work should include samples from this interval near the former tank locations to assess potential remaining soil contamination above the phreatic zone. The need for investigation beyond that planned will be determined by the additional data.

25.3.15 Site 15 - Sumps and Oil/Water Separators

Site 15 includes sumps and oil/water separators throughout the station. The sumps were generally for temporary storage of wastes prior to removal and disposal. Separators are for removing sediment and/or oil from waste streams prior to discharge to the sanitary sewer system. It is not known whether the sumps or separators have leaked their contents to adjacent soils. Known information and locations of the Site 15 sumps are as follows:

Sumps 25 and 42 - oil/water separator and vapor recovery sumps at the
NEX Station

Sump 54 - oil/water separator on the Hangar 3 apron (Site 7)

Sump 59 - near Tanks 16 and 17 at Site 4

Sump 58 - oil/water separator at Site 14

Sump 62 - at the Public Work's Paint Shop (Site 17)

Sump 63 - at the Equipment Storage Area (Site 13)

Sump 64 - near the northwestern corner of NAS Moffett Field

Sump 65 - neutralized battery acid sump at the southeastern Site 10

An investigation was not conducted at these sump locations in Phase I. Planned Phase II activities include sampling and analysis of liquid waste, and collection and analysis of shallow soil samples. The Phase II activities will be conducted during removal of the sumps.

Recommendations

Sumps are to be removed by the Navy. Any investigation needed will be identified by sampling and removal activities.

25.3.16 Site 16 - Public Works Steam Cleaning Rack

Site 16 is the public works steam cleaning rack (Sump 60) at the Public Works Vehicle yard. The site lies between the South Gate and Girard Road, near the southern part of Site 14. The wash rack pad consists of two catch basins which drain a concrete wash pad to an underground oil/wash separator. The wash rack is no longer in use and is scheduled for removal in the Fall of 1990. Its history of use, including volume and type of wash discharged, is unknown. Ground water at the site is not monitored, though the A and B aquifers are monitored at the nearby Site 14 and downgradient by a MEW well cluster.

An investigation was not conducted during Phase I. Activities to be included in Phase II are sampling and analysis of liquid waste; soil sampling from shallow borings; cleaning and inspection of the separator and catch basins; and removal of Sump 60. Sampling activities may be conducted concurrently with sump removal.

Recommendations

The need for additional investigation will be determined by the results of soil sampling, inspection, and removal activities.

25.3.17 Site 17 - Public Works Paint Shop Sump (No. 61)

Site 17 is Sump 61 which is located on the north side of the Paint Shop in Building 45, near the Old Fuel Farm at Site 9. The building is still used as a paint shop and has been active since the late 1930's, though the sump is no longer used. The sump is concrete, and received wastes from the paint shop which included oil- and latex-based paints, thinners, toluene, and turpentine. Types of wastes received from the adjacent Hangar 1 are unknown.

Phase I investigation activities were not conducted at Site 17. Activities scheduled for Phase II include sampling and analysis of liquid wastes from the sump and shallow soil sampling. Separate from the Phase II work, the Navy has plans to remove the sump in the Fall of 1990. The Phase II sampling may be conducted in conjunction with sump removal.

Recommendations

The results of Phase II and sump removal activities will determine the need for investigation beyond that planned for Site 17 and Site 9 in this area (see Section 25.3.9).

25.3.18 Site 18 - Dry Cleaner's Sump

Site 18 is the Dry Cleaner's Sump (No. 66) at the southern boundary of Site 9, north of Building 88 which was removed June 1990. Sinks and floor drains at the Dry Cleaner's shop flowed into the sump. The area is surrounded by paved parking and streets. On the east side of the building, a potential source existed at Site 14 north as Tanks 67 (removed June 1990) and 68 (found abandoned and filled with concrete).

The Phase I investigation for Site 18 was conducted as part of the Site 9 investigation and included a soil-gas survey and installation of one downgradient A2-subaquifer well. A previous investigation which showed soil and ground water contamination in the immediate area resulted in removal of the sump by the Navy (completed June, 1990). In this investigation, PCE was detected in soil samples from the saturated zone at levels of up to 6,900 ug/kg. A ground water sample from an A1-subaquifer well immediately downgradient of the sump contained up to 13,000 ug/l PCE and 1,900 ug/l TCE, as well as other chlorinated VOCs.

Findings

- The Site 9 soil-gas survey showed the highest concentrations of total ionizable compounds and TCE (up to 941,000 ppb) in the Site 18 area. Other chlorinated VOCs found by GC analysis include 1,1-DCA, 1,1,1-TCA, 1,1-DCE, and cis DCE. Toluene (up to 126 ppb) was also found in several samples from the west side of the site. These data are indicative of Sump 66 as a local source of chlorinated VOCs.
- Analysis of ground water samples from the downgradient Site 9 A2-subaquifer well, 200 feet north of Site 18, showed high levels of TCE (up to 36,000 ug/l). However, the dominant contaminant found in the previous investigation - PCE - was not detected above a quantitation limit of 1,000 ug/l. These data do not indicate that widespread contamination in the A2-subaquifer exists as a result of the Sump 18 sump.

Recommendations

Phase II work is not planned specifically for Site 18, however, several activities are planned in the immediately downgradient area as part of the Site 8 Phase II investigation. This investigation has been initiated and includes soil and ground water sampling in the A1 and A2 subaquifers. The need for investigation beyond the Site 9 Phase II work will be determined by the Phase II and sump removal investigations.

25.3.19 Site 19 Leaking Tanks 2, 14, 43, and 53

Site 19 includes tanks which are known to have leaked. These are Tanks 2, 14, 43, and 53, all of which were removed by the Navy in June, 1990. The tank locations and brief description are as follows:

Tank 2 - A 2,000-gallon waste storage tank installed on the east side of Hangar 3 in 1979. Waste stored included petroleum products, MEK, solvents, and cleaners from the Power Plant Shop.

Tank 43- A 200-gallon waste collection and storage tank installed on the northeast corner of Hangar 3 in 1979. Rinsewater from engine cleaning racks, drains, and sinks in Hangar 3 were collected in the tank. Wastes included oils and fuels, solvents, MEK, paint waste, and battery acids.

Tank 14 - A 1,700-gallon unvaulted, standby diesel tank south of Building 158 (the Line Shack).

Tank 53 - A 500-gallon unleaded gasoline tank at the northeast end of Marriage Road. The tank was for the golf course physical plant use.

The Phase I investigation specific to Site 19 was limited to the Tanks 2 and 43 area (Hangar 3, Site 7). The activities included deep borings to characterize the stratigraphy, installation of monitoring wells in the A2 subaquifer, sampling of shallow soil borings adjacent to the tanks, and aquifer testing to assess hydraulic characteristics of the aquifer. Investigation was conducted near Tank 53 as part of the Site 3 activities that included deep borings, installation of a downgradient A1-aquifer well, and shallow soil sampling in the nearby Marriage Road Ditch. An investigation was not conducted at Tank 14. Investigation during Phase II is not planned specific to Site 19; however, additional work is planned at Hangar 3 as part of Site 7 Phase II.

Findings

- Analysis of soil samples from Sites 7 and 19 well borings near Tanks 2 and 43 showed organic contamination. TCE and PCE were found in two soil samples from boreholes downgradient of Tank 43 at up to 13 ug/kg, and TCE at up to 110 ug/kg in soil samples collected adjacent to Tank 2. One soil sample from the opposite side of Tank 2 had TPHC at 110 mg/kg. These data indicate that some contamination is present in soils within a radius of about 20 feet around Tanks 2 and 43. Soil data from a well boring placed about 75 feet downgradient of Tank 53, and ditch samples within 100 feet of the tank did not show contamination.

- Inorganic analysis of soil samples showed several constituents above baselines, though, most were elevated only to levels which are considered to be within the range of natural variation of soil composition. However, concentrations of lead in two soil samples from a boring adjacent to Tank 2 (70 mg/kg and 75.8 mg/kg) were elevated significantly above the NAS baseline. Nickel was found at significantly elevated concentrations in one 1-foot sample from a boring about 400 feet north of Tank 43. The source of the nickel is not known. Analysis of soils from the well boring downgradient of Tank 53 showed some metals above the low baselines, but none more than slightly above NAS baseline.
- Ground water samples collected from the A1-subaquifer well downgradient of Tank 53 showed no degradation of water quality by organic or inorganic constituents other than that which has resulted from regional saltwater intrusion.
- Site 19 monitoring wells are completed in the A2 subaquifer and are located upgradient, immediately downgradient, and about 400 feet downgradient of Tank 43. Chlorinated VOCs were found in the highest concentrations (TCE up to 25 ug/l) in the immediately downgradient well, and in very low level concentrations (1,1,1-TCA and 1,1-DCA from 5 to 7 ug/l) in the one far downgradient well. These data confirm the existence of a low level chlorinated VOC plume in the Site 7 area. The upgradient well showed only single, low level occurrences of a few VOCs, indicating that Tank 43 is the source of contamination in this area, and that any contribution of VOCs to the A2 subaquifer from the upgradient Tank 2 has not migrated to the Tank 43 area. More significantly, data from W7-20(A2), placed immediately downgradient of Tank 2, did not show organic contamination above quantitation limits.
- Inorganic analysis of ground water samples from well W7-20(A2) and Site 19 wells did not show degradation of water quality other than that due to saltwater intrusion.

Recommendations

A Phase II investigation is not planned for the Site 19 tanks. However, the tanks have recently been removed by the Navy. Results of the investigations associated with these tank removals will determine the need for additional data gathering.

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